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ABSTRACT

This curriculum guide outlines the subject matter, techniques, and demonstrations presented to medical and paramedical personnel in a 1-week course offered at the New Mexico Pulmonary Center on the diagnostic evaluation of and the use of the most recent therapeutic techniques for children with chronic respiratory disorders. The manual's five sections are each divided into several content areas. Approximately one-third of the content is presented in outline form while the remainder is discussed in more detail and includes, in some instances, references, diagrams, and charts. The five sections with some representative subdivisions are as follows: (1) Basic Clinical Evaluation (Laboratory Evaluation and Pediatric Skin Testing by the Scratch Method); (2) Clinical Syndromes (The Mechanics of Ventilation and Respiratory Allergies in Children); (3) Acute Respiratory Emergencies (Acute Respiratory Failure and Mechanical Ventilation of the Lungs); (4) Supportive Therapy (Psychological Aspects of Children with Chronic Pulmonary Disease and Living with Cystic Fibrosis); and (5) Inhalation Therapy (The Principles of Inhalation Therapy and Inhalation Therapy for Infants). The appendix comprises about one-half of the manual and includes information on the Pulmonary Center; hospital aids such as a pediatric emergency cart; postural drainage instructions; airway obstruction; inhalation therapy; and pulmonary function aids such as the predicted values for maximum breathing capacity in children. (EM)

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# Community Visitation Training Program

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New Mexico Regional Medical Program
2701 Frontier, N.E.
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Albuquerque, New Mexico 87131

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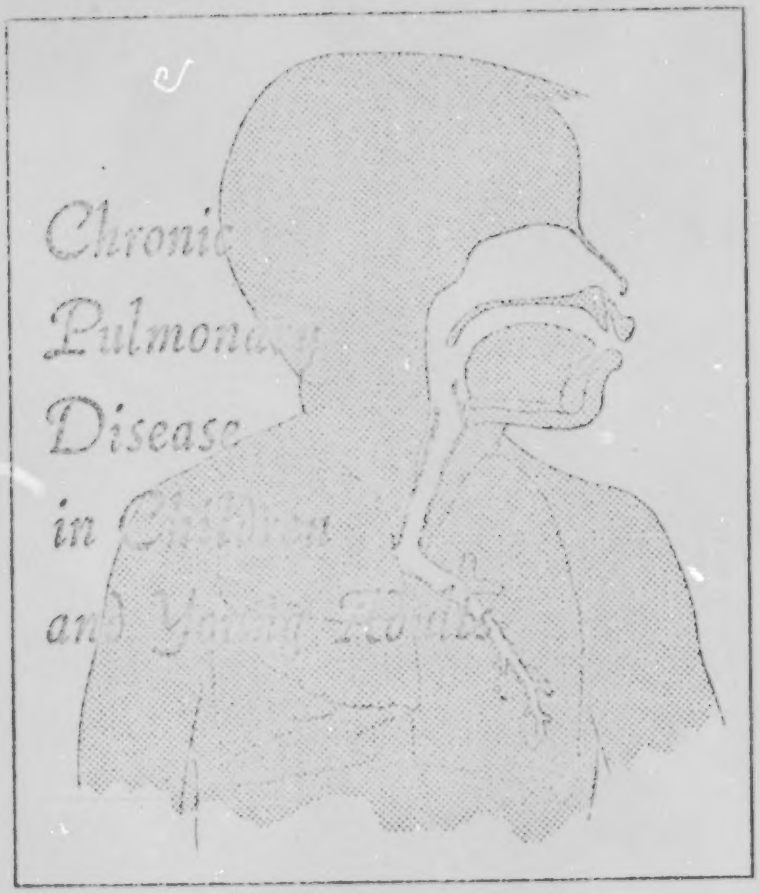


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SEPTEMBER 14 - 15, 1971

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## FOREWORD

One of the major objectives of the New Mexico Pediatric Pulmonary Center is to train and educate physicians, residents and interns, medical students, nurses, inhalation therapists, physical therapists, laboratory technicians and other paramedical personnel in the diagnostic evaluation of children with chronic respiratory disorders, and in the use of the most recent advances in therapeutic techniques in their treatment.

A major portion of the demonstration and educational program is conducted in the Center. This includes patient work-ups by externs, interns, residents and fellows; patient conferences; and lectures and demonstrations related to chronic pulmonary diseases in children. Our trainees have ample opportunity to gain practical experience in the clinical and physiological laboratories, and to work in the Center and in the hospital with our Inhalation Therapy and Physical Therapy staff. They may participate in one of our many research programs in collaboration with the Pediatric Research Department of the Lovelace Foundation.

In February, 1970, a Regional Post-Graduate Training Course was held at the Pediatric Pulmonary Center to provide such a training experience for medical and paramedical personnel of the Western United States. Approximately 120 registrants representing physicians, nurses, inhalation and physical therapists, and other paramedical personnel were in attendance. It is planned to hold such regional training courses every two years. In addition, smaller group courses will be held twice a year in the Center, devoting these sessions to the clinical-physiological-pathological relationships of respiratory diseases in children, as well as offering practical demonstrations and experience in pulmonary function testing and inhalation and physical therapy.

Another part of our educational-demonstration program is to hold two-day workshop sessions in the major communities throughout the state and region, by means of lectures and demonstrations. Registrants of these community visitation programs will be invited to attend the one-week Center courses later in the year.

This course manual will serve as an outline for the subject matter, techniques and demonstrations presented in this course. The techniques, methodology, dosages, and therapeutic regimens herein presented are those in use by this Center, and do not necessarily represent the only approach to the problems confronting those treating the child with chronic pulmonary disease. Approach this course with an inquisitive mind, feel free to participate in the periods designed for group discussions. We encourage you to call upon us at any time and hope that the course will prove to be interesting and profitable for you.

Roy F. Goddard

Roy F. Goddard, M. D.
Medical Director

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BACK COVER (INSIDE) DIRECTORY

SECTION I BASIC CLINICAL EVALUATION

DEMONSTRATION

ALLERGENIC SKIN TESTING

SWEAT TESTING

PULMONARY FUNCTION TESTING

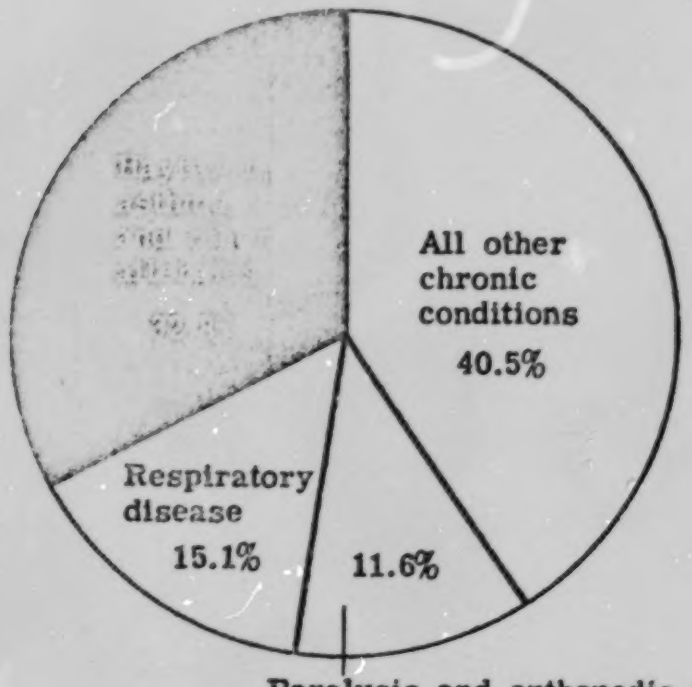
THE RECOGNITION AND EVALUATION OF

CHRONIC RESPIRATORY DISEASES IN CHILDREN AND YOUNG ADULTS

Roy F. Goddard, M. D.

Incidence and Importance of Recognition of Chronic Pulmonary Disease in Children

Forty-eight percent of all chronic conditions in children under the age of seventeen are due to allergy-respiratory conditions. This is a significant part of pediatric practice, so much so that we believe more emphasis needs to be turned to early recognition and treatment of these problems.



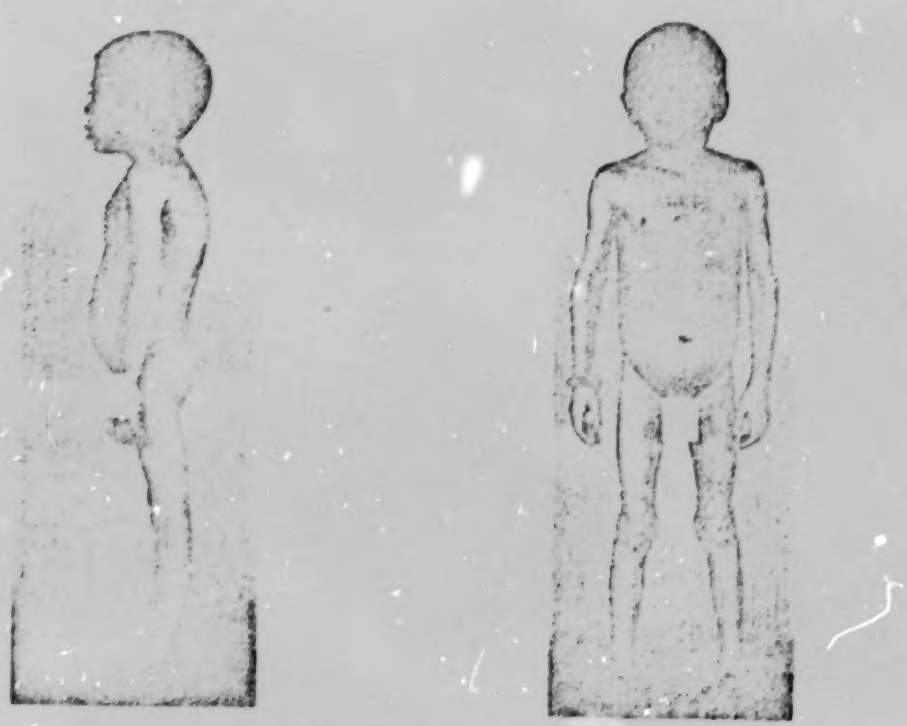

Incidence of Chronic Diseases of Children Under 17 Years of Age

## History

The more complete the physician's information, the more he will understand his patient's illness. This is accomplished, in part, through a thorough investigation of the family medical history and the history of the patient's illnesses in infancy and childhood. It will include diet and eating habits; colds and infections; seasonal ailments; medications which the child could not tolerate; inhalants such as pollens and animal danders; irritants such as dust, tobacco smoke or smog; environmental and emotional factors; exercise and physical competence to engage in various activities; a survey of previous medications, injections and treatment; and the type of symptoms, their severity and responses to medication.

## Physical Examination

Physical characteristics, such as the general appearance and stature of the patient are important. Variations from the normal range of height, weight and bone growth may reflect effects of illness. Appearance of the face, eyes, ears, nose, mouth and pharynx, and the color of the skin and nailbeds are of special significance in the child with respiratory involvement. The size, shape and symmetry as well as movement of the chest with breathing, are valuable aids in determining the functioning of the lungs. Other body systems are included in the complete physical examination, and related findings are correlated with respiratory findings.

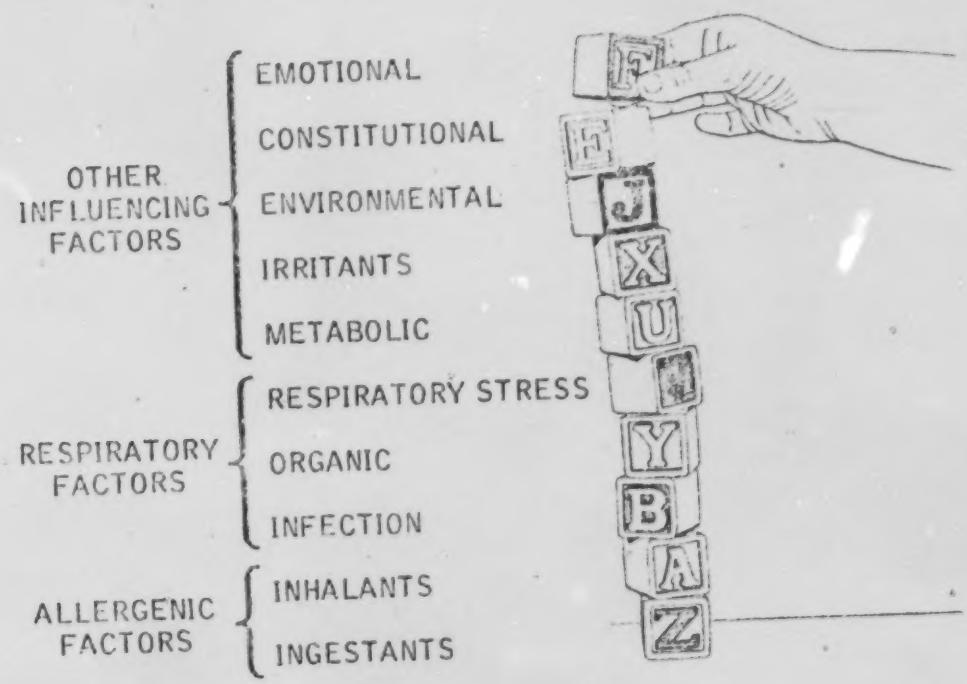


Seven-year old boy with cystic fibrosis. Note short stature, mild cyanosis of lips, increased AP diameter of chest and "pot-belly" appearance with poor subcutaneous tissues.

Preliminary Clinical Evaluation (prior to completion of laboratory studies)

An important part of the initial medical work-up of the child referred to the New Mexico Pediatric Pulmonary Center is a discussion with the parent(s) of factors contributing to his respiratory problem, and what may contribute to a "critical threshold" in his individual situation. Using this as an example of the factors which warrant evaluation, we then can proceed with some understanding on the part of the child and his parent(s) to the laboratory sutides, which are indicated in our investigation.

CRITICAL THRESHOLD IN
ALLERGY-RESPIRATORY PROBLEMS




Laboratory Studies

Blood Cell Count - A complete blood cell count will show the condition of the red and white cells and will give information indicating whether a child is chronically ill, allergic, or whether there is iron deficiency or superimposed infection present.

Sedimentation Rate - This is a valuable laboratory test in clinical allergy to rule out the presence of low grade chronic infection, which may frequently be a distressing complication in allergic children.

Urinalysis - Frequently, abnormal cells may be present in the urine of children with allergies or chronic respiratory conditions.

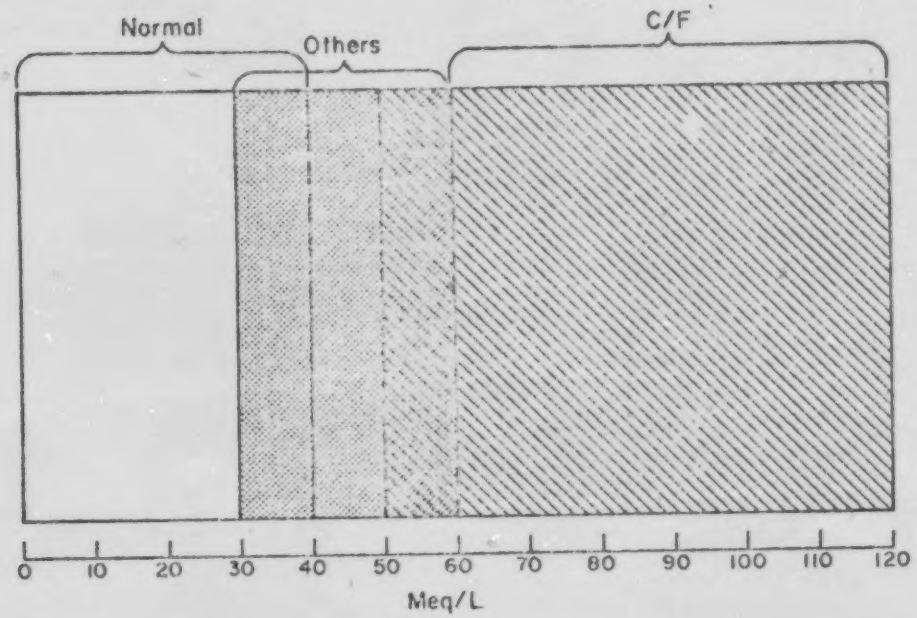
Nasal Smear - Certain types of cells called eosinophils may be present in fairly large numbers in children with allergies. If they are over ten per cent in number they may substantiate other evidence of allergy.

Throat and/or Sputum Culture - It may be important to know whether there are organisms present in the throat or sputum which are causing continuous or repeated bouts of respiratory infection. If indicated, a sensitivity study should be done to determine which antibiotic agents will be effective in the treatment of these infections.

Gamma Globulin and Immunoglubulin Levels - These may be useful in children with respiratory problems to enable the physician to determine whether the child is able to produce adequate antibody protection.

Sweat Electrolyte Determinations - This test should be done in children with allergic-respiratory conditions to rule out cystic fibrosis of the pancreas, in which condition the sweat electrolytes are elevated (see sweat chloride chart below).

SWEAT CHLORIDE



Acid-Base Studies - In chronic allergy-respiratory conditions, when there may have been prolonged interference with pulmonary ventilation, there may be disturbances in the balance of acid and alkali substances. It is important to know if these are sufficient to warrant corrective measures.

Secretions - It is frequently of value to examine the sputum or secretions from the naso-pharynx for quantity, quality and tenaciousness of the material. This will differ from the normal in respiratory and allergy situations.

Stool Examination - This may be of value in differentiating cystic fibrosis from other respiratory and allergic conditions. Special tests can be run as indicated.

X-Rays - X-Rays of the chest, including front and side views should be taken. These reveal the shape of the chest, whether there is any increase in length of the chest or increase of front-to-back diameter, the presence of over-inflation or air trapping, or evidences of infection. X-rays of the sinuses should be taken in all allergic-respiratory patients, including sufficient views to demonstrate the condition of these air spaces, and rule out adenoidal masses or nasal polyps.

Skin Tests - (a) Respiratory. Skin tests can be used to rule out tuberculosis and related conditions, as well as coccidiomycosis and histoplasmosis. (b) Allergenic Skin Tests. These tests are indicated in all respiratory -allergy evaluations in children over three years, and, may be helpful in selected cases in younger children or infants (especially food allergies). Clinical sensitivity to certain foods such as fish and nuts correlates more closely with skin reactions than sensitivity to every day foods such as milk, cereal, and eggs. The food tests are almost always done by the scratch method and only the commonly ingested foods usually need to be tested. In the toddler or pre-school child inhalants are generally the most important allergens. Usually skin testing is remarkably accurate for inhalants in this age group.

Pulmonary Function Tests - Pulmonary function tests can be divided into two categories. (a) Those that test the amount of air passing through the airways to the air spaces; and (b) those that determine the efficiency of the exchange of $CO_2$ and the oxygen across the alveolar-capillary membranes. These tests are very important in determining whether there is obstruction to the mechanical or ventilatory part of respiration and whether or not the gas which does get down to the lungs is able to diffuse into the blood stream and supply the body with adequate amounts of oxygen. Frequently it is difficult to obtain these studies in smaller children, and it may be necessary to repeat pulmonary function tests more than once.

Other Tests - When indicated, these should be included as part of the evaluation.

Summary of Allergy-Respiratory Evaluation and Recommended Therapy

Following our laboratory investigations, the child and parent(s) return for discussion and summary of our evaluation, together with an outline of proposed management for his problem. A letter and/or report is forwarded to the referring physician or agency following this initial evaluation of the patient. In certain cases the patient may be asked to return to the Pediatric Pulmonary Center for periodic follow-up visits.

References

Goddard, Roy F., "Respiratory Problems and Related Allergies in Children", Distributed by courtesy of Riker Laboratories, Northridge, California, 1966.

Goddard, Roy F., "Chronic Respiratory Problems in Children", Distributed by courtesy of Riker Laboratories, Northridge, California, 1966.

Schiffen, C. G., and Hunt, E. P., "Illness Among Children", Children's Bureau Publ. No. 405, Washington, D. C., U. S. Dept. of H. E. W., p. 14, 1963.

## LABORATORY EVAULATION

Center or Office

- Nasal Smear
- Throat or Sputum Culture
- Tine TEst

Clinical Laboratory

- CBC
- Urinalysis
- Total Proteins
- Immunoglobulins (Electrophoretic)
- Sweat Iontophoresis
- Liver Function (if indicated)
- Glucose Tolerance (if indicated)
- Others (as indicated)
- Allergenic Skin Tests

Cardio-Pulmonary

- Cardiac Catheterization (if indicated)
- Pulmonary Function
  - Restrictive Tests ) Lung Volumes
  - Obstructive Tests )
  - Intrapulmonary Mixing and Distribution
  - Flow-Volume
- Cardio-Pulmonary Competence
- Blood-Gas Analyses

X-Rays

- Chest
- Sinuses

# ALLERGY TESTING AND EVALUATION

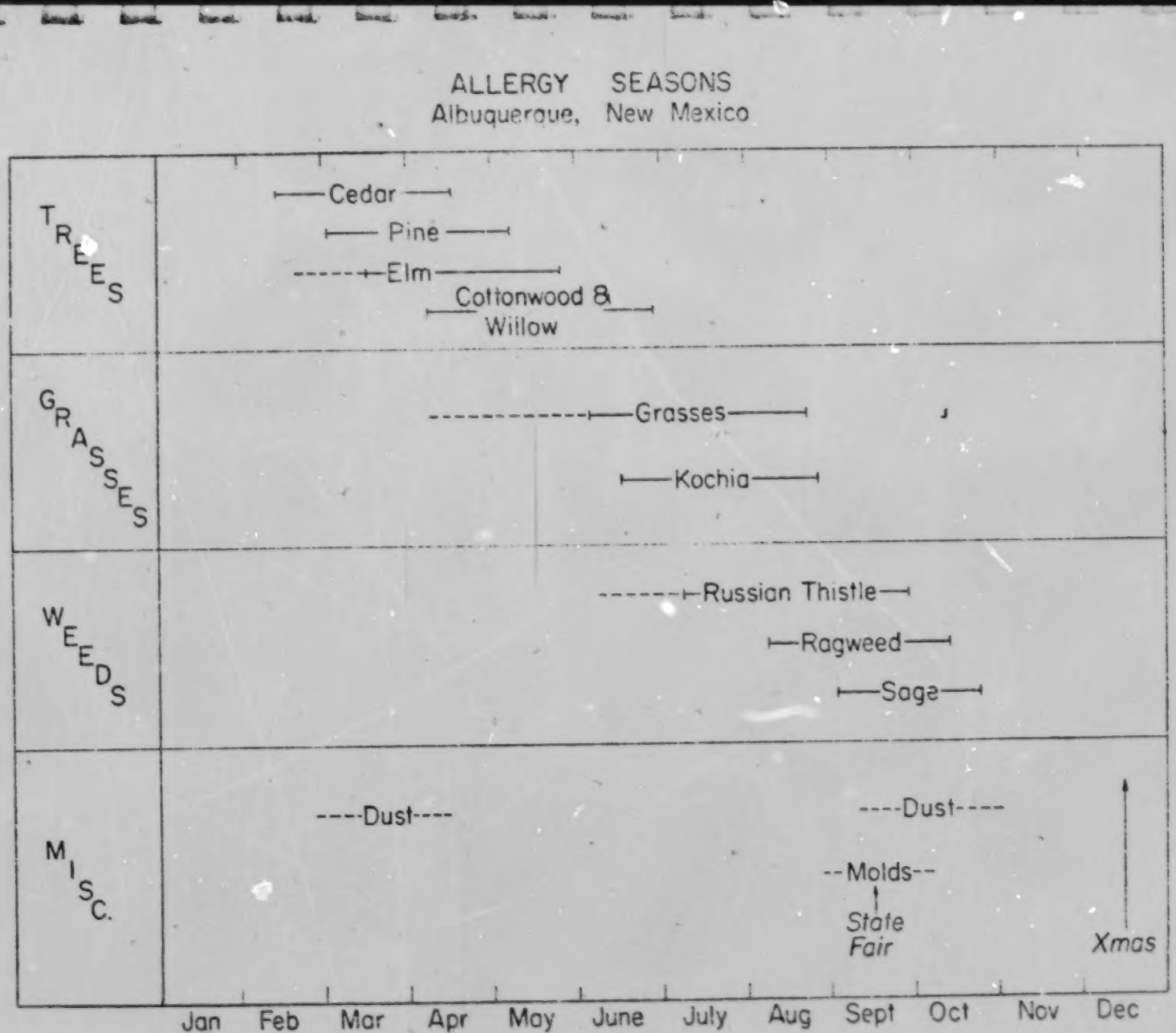
Roy F. Goddard, M. D.

An integral part of the allergy-respiratory evaluation is to study the allergenic sensitivity of the patient. It is estimated that 20 per cent of the normal population is allergic, this percentage is probably doubled in children with chronic respiratory diseases, including cystic fibrosis. A recent survey of chronic conditions in children under the age of seventeen reveals that 33 per cent of all chronic conditions in this age group result from allergies and asthma. Recently foods have been implicated in the "Tension-Fatigue Syndrome" and neurological conditions reversible by simple elimination diets.

It is, therefore, very important to determine the patient's sensitivities to foods and other ingestants (medications), irritants (dust, smoke, fumes), inhalants (trees, grasses, weeds, and molds), and animals with which he may come in contact.

We have employed the simple "scratch" test method in studying the majority of our patients. When a parent calls to our attention, or the history emphasizes a particular offending agent which does not respond to the "scratch" test, then we occasionally will do single intradermal tests as indicated. Other methods of studying sensitivity reactions, such as ocular and inhalant challenge are turned to in rare instances in our Center.

Of particular consideration in New Mexico is the fact that there seems to exist three geographical or zone areas or levels - certain pollens are present only in areas above 8,000 feet, others at our medium altitudes of 3,000 - 6,000 feet, and still others which grow along the Rio Grande and Pecos River valleys in the lower southern parts of the state. Allergy seasons may therefore vary slightly in different parts of the state.


ALLERGY SEASONS
Albuquerque, New Mexico
TREES
Cedar
Pine
Elm
Cottonwood & Willow
GRASSES
Grasses
Kochia
WEEDS
Russian Thistle
Ragweed
Sage
MISC.
Dust
Dust
Molds
State Fair
Xmas
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec

# PEDIATRIC SKIN TESTING BY THE SCRATCH METHOD

Mary Ann Zurek, R. N.

Allergenic skin testing is a part of the initial diagnostic work-up. This consists of eighty-four minute tests by a modified "scratch" method using selected allergenic extracts in a 1:20 strength.

It is highly recommended that the patient should not have taken any antihistamines in the twenty-four hours previous to the test, and that he have no elevation in temperature. He should also be as free as possible from any type of rash or skin manifestation.

The procedure is as follows:

Position - The patient should be lying face downward, arms at the sides, on an examining table or stretcher.

Site - The area of the patient's back between the shoulders and lower thorax.

Skin Preparation - The skin is cleansed with 70% alcohol (until clean!) then dried with a towel, paper or otherwise. This is to remove any soap film that might have been in the patient's clothes and have rubbed off on his skin. A graph is drawn on the back using a ball point pen with water soluble ink; twelve rows horizontally and nine vertically.

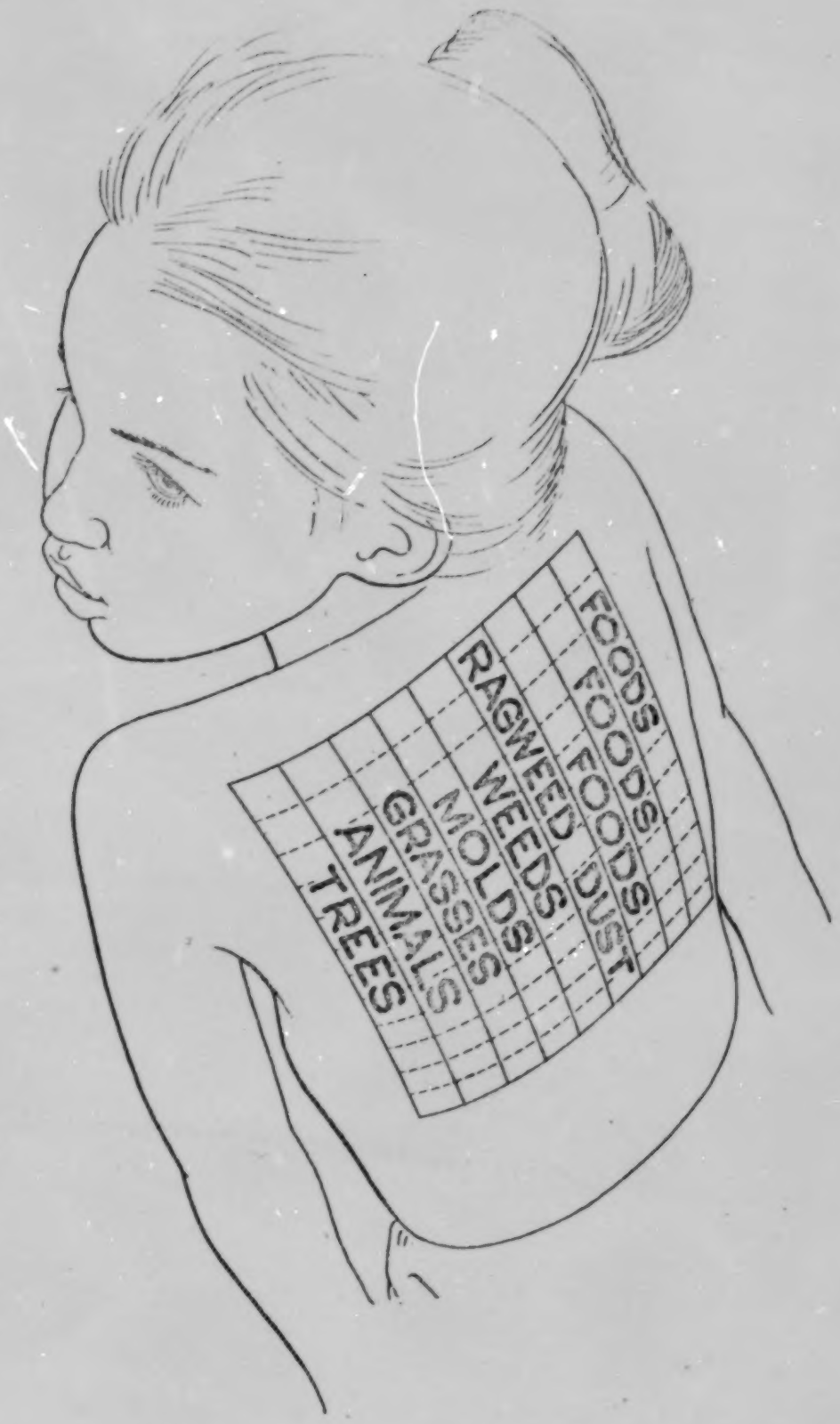
The allergenic extracts are divided in groups according to pollens from trees, weeds, grasses, dust, fungi, animal eipthelium and foods. A drop of allergenic extract is placed in each square of the graph according to the group in which it belongs and "pricked" with a fine, sterile sewing needle. Fifteen minutes after all the drops have been pricked lightly, they are wiped off with an alcohol sponge and "read". Reading is done visually and with the finger tips by the technician administering the skin test. Some pharmaceutical companies suggest the use of a scale rule to judge reactions to the extract in each test.

Reactions are judged by size and erythema, if present. A tiny hive is a 1+; a larger hive is a 2+; a hive with a moderate amount of erythema, slightly larger than a 2+ is a 3+; and a hive of any size that is irregular (with pseudopods) is a 4+. These reactions are recorded on an allergy test sheet and given to the doctor requesting the test. The skin test report will be evaluated by him.

After the skin test is completed and "read" the patient's back is washed lightly with 70% alcohol and dried as before.

Re-testing is recommended every two years to determine changes in sensitivity resulting from the patient's program, or the development of any new sensitivities.

Food sensitivities are controlled by elimination diets. Animal avoidance is strongly recommended for those allergic to animals. Desensitization is carefully programmed for those allergic to dust, molds, trees, grasses and weeds.


FOODS
FOODS
FOODS DUST
RAGWEED
WEEDS
MOLDS
GRASSES
ANIMALS
TREES

# HYPOSENSITIZATION PROGRAM AND DOSAGE SCHEDULE

Roy F. Goddard, M. D.

Following the "scratch" test or other allergenic sensitivity tests, a careful review of the patient's sensitivities is made and an individual hyposensitization program is outlined. An aqueous extract is made up as described and the dosage schedule is outlined.

Currently, we are using only an aqueous preparation, and do not recommend Alypryral or repository injections. Shots are given by a nurse; each patient is re-examined and questioned 20 minutes after the shot has been given for local or systemic reactions. If there is itching, Periactin (or similar drug) is given; if the reaction os moderate or severe, then other medications may be given orally, locally, or IM (adrenaline, susphrine) as indicated. One should be prepared to counteract any undesired reaction and should have adrenaline on hand at all times. It may be advisable to lower dosages during allergy seasons, particularly if the pollen count is high while the particular agent is being administered. Daily pollen counts are valuable in controlling and planning hyposensitization programs. From such daily counts we hve maintained over the years, we have been able to plot rough allergy seasons for guidance in our hyposensitization programs.

We usually give weekly injections in graduated dosages until an optimal maintenance dose is reached. This may be 0.40 cc. of the 1:50 dilution or less, depending on reaction. We give the maximum dosage below that which does not produce local or systemic reactions. We try to start our hyposensitization program before allergy seasons begin. If this is not possible, then we proceed cautiously in order that we may build up sensitivity as rapidly as possible. In those individuals that are extremely sensitive or have severe allergic manifestations, we may start with a 1:50,000 dilution. However, in most of our patients we start with the 1:5,000 dilution and proceed as outlined. When the optimal maintenance dose has been reached, this is either continued on a weekly basis, or may be given every 2, 3, 4, or more weeks, depending on control of allergic manifestations of the patient. If symptoms return during allergy seasons, then frequency of injections are regulated accordingly.

RECORD OF DESENSITIZATION AND INHALATION THERAPY PROGRAMS

Name _____ Age _____ Clinic Number _____

Diagnosis _____ Treatment (1) _____

Extract (1) Type _____ (2) _____

(2) Date _____ (3) _____

| DATE | RX NO. | INHALATION THERAPY Aerosol | Pressure cm. | Duration mins. | DESENSITIZATION Dose No. | Vial No. | Amount cc. | Reaction | OTHER SHOTS |
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## SWEAT TEST USING IONTOPHORESIS AND PILOCARPINE SOLUTION

The sweat test is for diagnosing cystic fibrosis of pancreas (diffuse exocrinopathy or mucoviscidosis). Pilocarpine iontophoresis is the method used to induce sweat in a localized area. The collected sweat is analyzed for the concentration of chloride ions.

Procedure

1. Wipe a hair free area on the volar aspect of the forearm with an alcohol sponge followed by distilled water and then dry. This is the test area.

2. Insert a white filler paper disc into each of two plastic retainer rings. Place a retainer ring on each electrode such that the disc seats well against the the electrode (there will be a slight bowing of the paper disc at the center due to the stiffness of the paper).

3. Insert the center post of the first electrode through the first hole of the rubber strap such that the small electrolyte filler hole is not covered by the strap. Insert the second electrode center post through the hole of the rubber strap so that the two electrodes are located opposite each other when applied to the arm.

4. Soak the first filler paper disc with pilocarpine nitrate and the second paper disc with sodium nitrate.

5. Place the pilocarpine electrode paper disc in contact with the test area. As previously measured, strap the sodium nitrate electrode to the forearm and secure the strap to the first electrode through a convenient hole.

6. Connect the white lead to the center post of the electrode (pilocarpine nitrate) located on the inner forearm and connect the black lead to the center post of the electrode (sodium nitrate) located on the outer forearm.

7. Place white tip lead in red outlet and black tip lead in the black outlet on the amp-volt meter machine.

8. Switch on machine. Slowly turn the milliamperage knob clockwise and raise the current to a maximum of 1.5 milliamps. Allow the current to run for 5 minutes.

9. To insure that the pads stay wet during the entire stimulation period, moisten the pads by means of applying solution through the filler hole of the respective electrode.

10. After five minutes, reduce milliamperage to 0, turn the machine off, disconnect the leads from the electrodes and remove the electrodes from the arm.

11. Wipe the arm dry. Let the test area be exposed to the air for approximately 5 minutes. Wash the pilocarpine test area (inner forearm) with distilled water and dry by using 4 x 4 inch gauze pads. Place the plastic sweat collection cup over the area of iontophoresis (inner forearm) and tape it securely to the arm with non-wettable adhesive tape in order to provide a positive seal. Allow approximately 25 minutes for the sweat to collect under the collecting cup.

12. Remove the tape from the arm while holding the cup securely against the arm. Position the patient's arm such that the cup is either on the side or under the arm and remove the cup by sliding its edge over the iontophoresed area. This sliding technique collects the sweat into the cup and allows it to "puddle", reducing the rate of evaporation and redesolving any salts left in the area by evaporation within the cup.

13. After removal of the sweat collection cup, aspirate all sweat available with a 20 microliter disposable pipet and place in a plastic microcentrifuge tube and cap.

14. Label plastic microcentrifuge tube and forward along with the laboratory form to the Biochemistry Section.

NOTE: Periodically check batteries by turning control to maximum clockwise position. Needle should deflect on voltage meter to within green band and indicates that batteries are at proper strength.

Advantages of Modified Sweat Iontophoresis Test

1. Compact
2. Small electrode (less resistance)
3. Same extremity
4. Ambulatory
5. Direct measurement
6. Standard biochemical titrimetric analysis
7. Disposable fillers and collection cup.

Equipment required for Sweat Test

A simple amperage-voltage meter is put together by our electronics people and the Heat Technology Laboratory electrodes, including retaining rings and filler papers, as well as their pilocarpine and nitrate solutions along with the collection cups are used for obtaining "free" sweat. The sweat chloride is determined by a cotlove chlorodometer rather than relying upon an electric impedance principle. We have used various impedance principles in the past and found them rather hard to standardize as the cations and the anions influence the standardization. We prefer to determine the actual chloride content by a proven laboratory technique.

We have had poor success in obtaining sweat from youngsters less than 4 - 6 months of age. Their eccrine sweat glands are just not well developed until about 6 months of age.

The cost of the basic equipment, provided the amperage-voltage meter is locally constructed is somewhere around $100.00 + $10.00. A battery operated sweat inducer is commercially available from Buchler for approximately $85.00. Continuing costs would be in the procurement of the solutions, retaining rings, paper fillers and cups from Heat Technology Laboratory.

# PULMONARY FUNCTION

Judy Elstner and Piyanan Sithiku, M. D.

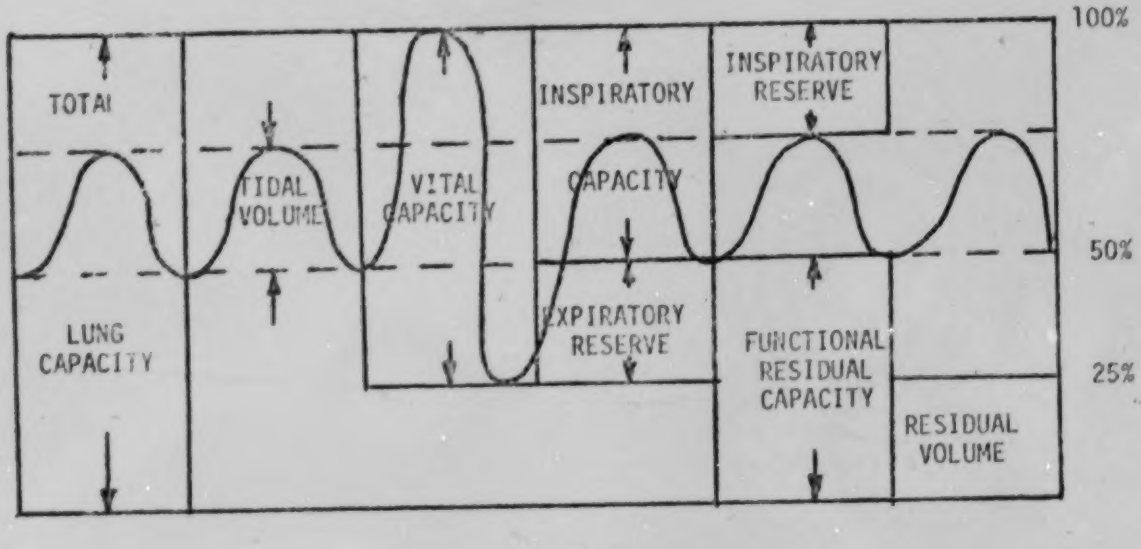
The evaluation of pulmonary function can be divided into four categories:

1) Determination of lung volumes
2) Determination of pulmonary efficiency, i.e., exchange of $O_2$ and $CO_2$ across the alveolar-capillary membranes
3) Determination of rate of air flow through the airways
4) Blood-gas analysis.

## I. Lung Volumes

### A. Definitions

The following diagram depicts lung volumes which can be measured by various pulmonary function tests, also indicating their relative size in a normal healthy individual.




Total Capacity (TC)is divided into the following subdivisions:

1. Tidal Volume (TV): the amount of air moved in and out of the lungs during quiet breathing
2. Vital Capacity (VC): the amount of air that can be forced out of the lungs after a maximal inspiration

3. Inspiratory Capacity (IC): the maximum amount of air which can be inhaled at the end of a normal expiration
4. Inspiratory Reserve (IR): the additional amount of air which can be inspired at the end of a normal inspiration
5. Expiratory Reserve (ER): the additional amount of air which can be forced out of the lungs at the end of a normal expiration
6. Functional Residual Capacity (FRC): the amount of air remaining in the lungs at the end of a normal expiration
7. Residual Volume (RV): the amount of air remaining in the lungs at the end of a forced expiration. This amount of air cannot be willfully expelled from the lungs.

The absolute values obtained for the various lung volumes can be compared with predicted normal values, which are usually correlated with height. Also of importance is the relative proportion of the various lung volumes. There may be an increase in the proportion of residual volume and functional residual capacity to total capacity in individuals with considerable air trapping.

B. Measurement of Lung Volumes

Tidal Volume, Vital Capacity and its subdivisions (IC, IR, ER) are most commonly determined by spirometry. For the determination of Total Capacity, Functional Residual Capacity and Residual Volume, the nitrogen clearance test is used. This test is technically more sophisticated than spirometry and must be performed in a specialized pulmonary function laboratory rather than in the hospital or physician's office.

II. Pulmonary Efficiency

The nitrogen clearance test also indicates the mixing efficiency of the lungs by determining the amount of air needed to clear the nitrogen from one liter of the patient's FRC when breathing pure oxygen. This value is called the Clearance Equivalent. A high value for the Clearance Equivalent indicates poor mixing and distribution of gases in the lungs.

Another test available for measuring pulmonary efficiency is the determination of Diffusing Capacity, a measurement of the rate of diffusion of gas across the alveolar-capillary membrane. Low concentrations of CO are used for this purpose, as it combines readily with Hb, thus giving a clear picture of the amount of gas moving from the lungs into the blood.

III. Air Flow

Determinations of air flow can be made by the spirometric measurement of forced vital capacity and the calculation of volume expired per second, or by more sophisticated equipment which records a flow-volume loop. A decrease in rate of air flow is common in patients with obstructive pulmonary disease. These tests can be performed before and after bronchodilator or other appropriate treatment to obtain a quantitative indication of the treatment's effectiveness.

IV. Blood Gas Analysis

Blood gas analysis determines how adequately the lung has accomplished its primary purpose, that is, ventilation, perfusion, and diffusion. Analysis of peripheral venous blood is a poor measure of pulmonary function because the $O_2$ and $CO_2$ in the venous blood from any part of the body, or even of mixed venous blood, depends not only on the $O_2$ and $CO_2$ in the arterial blood, but also on the metabolism and rate of blood flow through the tissues.

Several acceptable methods of obtaining arterial blood in children exist. In newborn infants, the easiest and most reliable source is from an indwelling catheter advanced into the umbilical artery until free flow of blood is obtained. Another method is to use the anterior temporal artery for puncture with a winged #24 or #25 gauge needle. One can also obtain arterialized capillary blood from a heel, finger or ear lobe by warming up the extremity or ear lobe for 10 to 15 minutes. By this method blood is collected in heparinized capillary tubes with a piece of metallic wire serving as a stirrer. In every instance blood is collected under anaerobic conditions, stored in icewater and analyses done immediately. In older children brachial or radial arterial puncture can be used.

The important measurements of arterial blood, however collected, include pH, $PO_2$ and $PCO_2$. From these three values one can derive $O_2$ saturation, using $PO_2$ and pH on a standard $O_2$ dissociation curve. $CO_2$ content, bicarbonate, and base-excess or deficit with additional measurement of hemoglobin can be read directly from the Siggaard-Anderson nomogram. Acid-base diagrams can then be utilized in determining and following the variations in acid-base of a patient.

TESTS WHICH CAN BE PERFORMED WITH COLLINS SPIROMETER[1] IN OFFICE OR HOSPITAL

| Values | Effort Required | Comments |
|---|---|---|
| VC<br>$FEV_1$<br>MBC[1]<br>MMEF | Forced Expiration[2] | Accurate, easy to perform and calculate |

1. These tests are performed with a Collins Spirometer in the Pediatric Pulmonary Function Laboratory of the Pediatric Pulmonary Center, but can also be performed with the Jones Pulmonor or McKesson-Robbins Vitalor. With these machines, values can be read directly from the tracing, but at the cost of accuracy.

2. A forced maximal expiratory effort may be difficult to obtain in children under six years of age.

3. Definitions:

   VC or Vital Capacity - the amount of air that can be forced out of the lungs after a maximal inspiration; it normally represents 70 to 75% of Total Lung Capacity.

   $FEV_1$ or Forced Expiratory Volume in one second - the amount of air exhaled in the first second of a forced maximal expiration after a maximum inspiration. This volume can also be expressed as a percent of the Vital Capacity.

   $\frac{FEV_1}{VC} \times 100$ A normal individual can expire 83% of his Vital Capacity in one second (with 75% as a lowest limit of normal).

   MBC or Maximal Breathing Capacity - the maximal volume of air that can be moved in and out of the lungs in one minute. The formula for the indirect calculation of MBC is:

   $MBC = FEV_1 \times 37$ MBC is directly related to $FEV_1$ (See above) and can be compared with tables of normal values on the basis of the individuals' height, weight, age, and body surface area.

   MMEF or Maximal Mid-expiratory Flow - the mean flow rate in liters/second during the middle 50% of a forced expiration starting from full inspiratory level; in a normal individual, the MMEF should be numerically equal to 2/3 of the Vital Capacity.

TESTS WHICH CAN BE PERFORMED IN THE PEDIATRIC PULMONARY FUNCTION LABORATORY OF THE NEW MEXICO PEDIATRIC PULMONARY CENTER

| Test | Values | Effort Required | Comments |
|---|---|---|---|
| $N_2$ Clearance | FRC, RR, RMV, mixing efficiency | Resting breathing on $O_2$; subject must remain on the mouth-piece without inter-ruption until test is completed. | Accurate, complex equipment, highly trained personnel. |
| $N_2$ Clearance in combination with spirometry | TC, RV, TV, VC, IC, ER, FRC, MBC, MMEF, RR, RMV, mixing efficiency | Maximal inspiration and expiration, forced expiration, resting breathing on $O_2$ and room air. | Accurate, complex equipment, highly trained personnel. |
| Flow-Volume Loop | PEF, MMEF, MMIF, FVC | Forced expiration and inspiration. | Accurate, complex equipment, highly trained personnel. |
| Diffusing Capacity CO steady-state | $D_{L_{CO}}$, $F_{U_{CO}}$ | Resting breathing on room air plus CO. | Accurate, complex equipment, highly trained personnel. |

Arterial blood gas studies can also be performed. Simultaneous collection of arterial blood samples and expired air permits estimation of alveolar ventilation and alveolar-arterial oxygen gradient in addition to $PCO_2$, $PO_2$, pH and $BHCO_3$.

Cardiopulmonary competence can be evaluated by measuring oxygen consumption during maximal physical exertion at the limits of the individual's aerobic capacity. This test is performed on a bicycle ergometer at work loads appropriate to the test subject's size.

## DEFINITIONS OF PULMONARY FUNCTION TERMS

Total Capacity (TC): total volume of air in the lungs at the end of a maximal inspiration.

Vital Capacity (VC): the amount of air that can be forced out of the lungs after a maximal inspiration.

Inspiratory Capacity (IC): the maximum amount of air which can be inspired at the end of a normal expiration.

Inspiratory Reserve (IR): the additional amount of air which can be inspired at the end of a normal inspiration.

Expiratory Reserve (ER): the additional amount of air which can be forced out of the lungs at the end of a normal expiration.

Tidal Volume (TV): the amount of air moved in and out of the lungs during quiet, resting breathing.

Functional Residual Capacity (FRC): the amount of air remaining in the lungs at the end of a normal expiration.

Residual Volume (RV): the amount of air remaining in the lungs at the end of a forced expiration.

Forced Vital Capacity (FVC): measurement of vital capacity obtained by having the patient perform a forced maximal expiration after a maximal inspiration.

Maximal Breathing Capacity (MBC): the maximal volume of air that can be moved in and out of the lungs in one minute.

Respiratory Rate (RR): number of breaths per minute during resting breathing.

Respiratory Minute Volume (RMV): volume of air moved in and out of the lungs during one minute of resting breathing.

Peak Expiratory Flow (PEF): the maximal rate of air flow in liters/second during a forced maximal expiration.

Maximal Midexpiratory Flow (MMEF): the mean flow rate in liters/second during the middle 50% of a forced maximal expiration.

Maximal Midinspiratory Flow (MMIF): the mean flow rate in liters/second during the middle 50% of a forced maximal inspiration.

Diffusing Capacity ($DL_{CO}$): measurement of ml CO transferred per minute for each mmHg pressure difference for CO across the alveolar-capillary membrane.

Fractional CO Uptake ($FU_{CO}$): CO absorbed per minute/CO inspired per minute.

SECTION II CLINICAL SYNDROMES

THE MECHANICS OF VENTILATION

NORMAL VENTILATION

TYPES OF IMPAIRMENT

ABNORMAL VENTILATION

RESPIRATORY ALLERGIES OF THE UPPER RESPIRATORY SYSTEM

RESPIRATORY ALLERGIES OF THE LOWER RESPIRATORY TRACT

ASTHMA

BRONCHITIS

BRONCHIECTASIS

CYSTIC FIBROSIS

EMPHYSEMA

# THE MECHANICS OF VENTILATION

## Normal Ventilation in Children

Ventilation consists of passage of gases (air) through the airways to the lungs and thence across the pulmonary membranes into the blood stream. Three main factors influence the movement of air: (1) resistance to the flow of air through the airways, (2) elasticity of the lungs, and (3) non-pulmonary forces, producing movement of the lungs and chest, such as contraction of the muscles of the chest wall and movement of the diaphragm.

## Types of Impairment

1. Obstructive - occurs when there is reduction in the diameter of the airways.

2. Restrictive - may be due to (a) defects in the chest wall, such as diseases of the respiratory muscles, "pigeon breast" chest, sunken chest, rickets, or missing ribs, (b) restriction of lung movement by disorders of the pleura. The pleura is the membrane covering the lungs like a bag; it extends over the inner surface of the chest wall forming a space, the pleural cavity, which contains a lubricating fluid so that the lungs may move without rubbing against the chest wall. Infection (pleurisy) may produce pain or increased amounts of fluid, which, in turn, limit the movement of the lungs. (c) Collapse of the lung (atelectasis) may occur in small areas or as collapse of an entire lobe. (d) Loss of compliance or the ability of the lung to move. The lungs move as a balloon that is alternately inflated and deflated, or as a bellows. The lung tissue acts as a sponge. When compliance is decreased the lung does not move as easily as it should and the sponge-like tissue becomes soggy so that it does not snap back to normal on exhaling.

3. Dynamic Impairment - The dynamic control of ventilation is concerned with the nervous and muscular forces involved in breathing. Causes of dynamic impairment are: (a) loss of elasticity, which may be due to chronic stretching of the muscles of the chest wall so that the thorax is no longer elastic; (b) neuromuscular defects, which may be congenital or the result of infection, as in poliomyelitis, or may be caused by certain poisons; (c) inadequate control from the central nervous system which regulates breathing; when this does not function as it should, as in head injury or drug intoxication, normal movement of the chest does not follow and some dynamic impairment will occur.

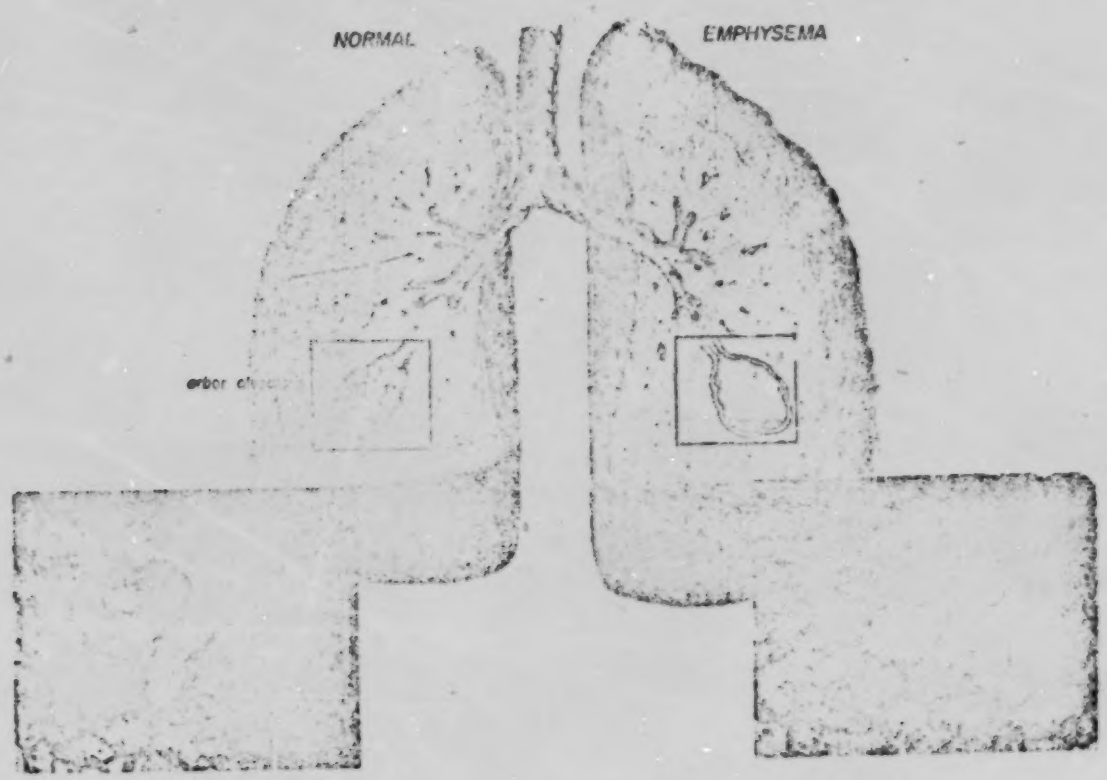
## Abnormal Ventilation

1. Obstruction - Any reduction in the size of the airway results in obstruction to the flow of air and limits the automatic, easy and unrestricted breathing of the normal person. Obstruction may be due to bronchospasm or closing down of the smallest tubes in the bronchial tree (the bronchioles). The bronchioles have muscle bands wrapped spirally around them. Just as a rubber tube closes when pinched, these tiny airways close when the muscle bands contract and breathing becomes difficult. In addition to bronchospasm there may be thickening of the walls of the bronchi and an abnormal amount of secretions may be present.

2. Hyperaeration - With obstruction there is usually a resultant increased resistance to the flow of air in and out of the lungs, causing the body to work

harder in emptying and filling the lungs. The problem is getting stale air out of the lungs and fresh air in. Stale air is trapped in the lungs and this is called hyperaeration. If sufficient air trapping occurs, the lungs cannot empty normally, the chest size increases, pushing the ribs farther apart and expanding the chest in all diameters. The diaphragm also becomes flattened and breathing is seriously hampered.

3. Destruction - If obstruction and hyperaeration persist for a long time there may be added complications. The spongy lung tissue loses its elasticity and the walls of the alveoli break down. The normal grape clusters of air spaces (alveoli) then form larger air spaces, and these become filled with secretion. Although the air spaces may become larger there is less wall area through which the exchange of oxygen and carbon dioxide can occur. Breathing becomes even more restricted and there is less capacity for physical exertion. The seriousness of the lung disease depends to a great extent upon the duration of the obstruction and hyperaeration as these determine the extent of destruction of lung tissue. If one can decrease or remove the obstruction, usually the hyperaeration can be overcome before destruction sets in, and the process is reversible or temporary.



The Upper Respiratory System

1. The Eye - There may be edema or swelling of the eyelids or around the eyes. This swelling may be accompanied by secretions or discharge, causing the eyelids to stick together. The membrane covering the inner surface of the lids and the surface of the eye may be markedly inflamed. This is usually accompanied by itching of the eyes and excessive production of tears.

*Normal vs. Allergic Nose*

2. The Nose - There may be itching of the nose with resultant rubbing, sniffing and episodes of sneezing. In acute nasal allergy there is usually considerable watery discharge. The nostrils may be quite large and flared and frequently there is crusting and loss of the lining of the nostrils. Chronic symptoms are usually due to blocking of the nasal passages and this causes the child to complain of stuffiness of the nose. He attempts to relieve this feeling by blowing his nose. If the blockage is marked, the child is forced to breathe through his mouth, and snoring and restless sleep occur. Usually in the morning, on arising, sneezing and nasal itching occur. In an effort to obtain relief he frequently develops a characteristic mannerism which has been described as the "allergic salute." The tip of the nose is elevated by the palm of the hand and the nose and mouth are wrinkled from side to side. Children with chronic allergic rhinitis frequently develop the so-called allergic facies.

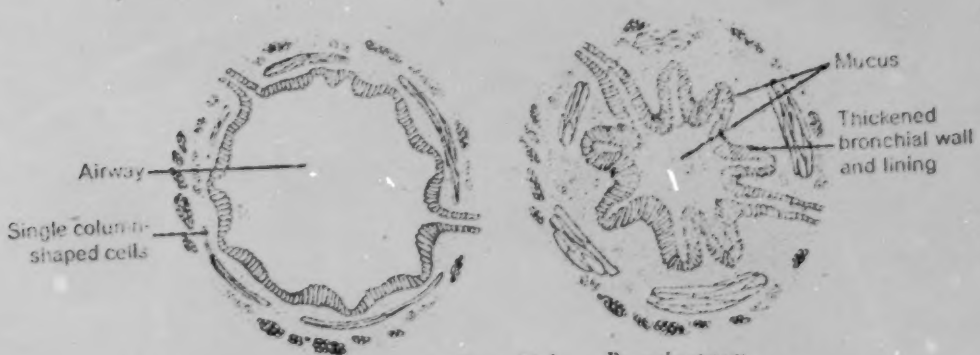
3. The Sinuses - Nasal discharge is usually frequent and may be especially marked in the mornings, resulting in snorting, sniffling, and throat-clearing. Non-productive coughing begins at bedtime and continues throughout the night. As previously mentioned, the sinuses empty into the nose, into the areas of the upper, the middle and lower turbinates. Frequently, when there is sufficient obstruction of the sinus openings, there is irritation and secondary infection of the sinus areas. In about 80 per cent of children with upper respiratory allergies, the sinuses be involved to some extent. There may be thickening of the walls of the sinuses and in many instances an accumulation of fluid, particularly in the maxillary sinus. The physician usually watches the sinuses closely in the allergic child so that secondary infection and post nasal drip can be avoided.

## THE LOWER RESPIRATORY TRACT

1. The Trachea or Windpipe - Just as the back of the pharynx may become irritated and itch, so may the wall of the trachea or windpipe become irritated, with production of mucus and secretions which rattle up and down in the windpipe. The trachea may become thickened and may be pushed out of position under certain conditions.

2. The Bronchi - The bronchi are the main branches of the windpipe or trachea. The branching subdivisions of these are called bronchial tubes. The major portion of respiratory obstruction or spasm occurs in the narrowest of these bronchial tubes, the bronchioles. The normal bronchiole is an open tube lined with single, columnar cells having microscopic hair-like structures on the surface which help in the movement of mucus or foreign substances. Between these cells are the mucus secreting cells. During inhalation the bronchioles enlarge lengthwise and shorten during exhalation. Accompanying the muscles are small bundles of nerves through which most of the nervous control of breathing is transmitted. These nerve fibers may be influenced by disturbances in other parts of the body (e.g. an upset stomach may trigger a message to the brain which sends a message to the nerve endings in the bronchioles causing bronchospasm).

3. Bronchospasm - Bronchospasm may be due to the inhalation of pollen or an irritating substance or eating such things as shrimp or other foods which may cause an acute reaction. Bronchospasm, as previously described, is due to the contraction of the muscle bands wrapped spirally around the bronchioles, decreasing the size of the air passages during the spasm. There is accompanying thickening of the bronchial cells and there is an increase in the number of mucous glands and in their secretory activity. This produces large amounts of thick tenacious mucus. There is usually an increase in the amount of blood in the capillaries. These factors cause narrowing of the smaller bronchioles. Infection may further increase breathing difficulty.




*Normal Bronchiole vs. Bronchospasm*

4. Wheezing - The secretions in the bronchi and bronchioles are characteristically thick and stringy and if there is sufficient drying, the mucus may become thick enough to form plugs that obstruct air passages of almost any size. Wheezing usually occurs during exhalation. As the individual breathes in, the bronchioles elongate, allowing air to pass the mucus in the bronchioles. During exhalation the bronchioles shorten and close down on the mucus plug, which acts like a ball-valve obstruction. The air rushing past the mucus plug causes a sound, usually described as "wheezing". This may be audible to the unaided ear; often one can feel mucus rattling in the bronchi or bronchioles by placing a hand on the chest and feeling the vibration caused by the air trying to rush past the obstructed areas when mucus is plugging the airways.

This bronchial obstruction interferes with pulmonary ventilation, resulting in trapping of air in the alveoli, which tends to increase with each respiratory cycle and contributes to less efficient ventilation.

# ASTHMA

Although parents usually define asthma as wheezing, there are many causes of wheezing, other than the allergic conditions associated with asthma. Some of these may be an obstruction of the upper respiratory tract due to mucus vibrating in the nasal passages and the pharynx or the presence of a foreign body such as a coin lodged in the larynx, trachea, or main bronchi. "Asthmatic bronchitis" has been defined as a typical expiratory wheezing associated with infection in the respiratory tract and is observed frequently in infants and children. There is a difference between allergic asthma and wheezing due to infection, although this distinction cannot always be made. The characteristic picture in the latter is usually that of a child who, after 24 to 72 hours of an upper respiratory involvement with nasal discharge, congestion and cough, develops a typical wheeze, during exhalation without appearing ill. Usually there is a history of wheezing with each bout of an upper respiratory infection, with a decrease in severity as the child develops resistance to the bacteria.

The onset of asthma may be gradual or abrupt. Asthma due to pollen can appear in an individual who has never experienced seasonal hay fever. Attacks vary greatly in frequency, depending on age, cause, or association with infection and duration of the disease. Attacks may be seasonal or occur throughout the year. Asthma may be periodic although exposure to the offending allergen may be continuous.

Asthma in infancy is common. Approximately 20 per cent of childhood asthma may have its beginning in the first year of life. In children, with the use of all known therapeutic measures, it is possible to control at least 90 per cent of all cases. Many children will "outgrow" their affliction or be better able to tolerate it by the time they enter high school. It is during puberty that the child begins to produce hormones which in some measure may influence the course of his asthma. It is impossible, however, to differentiate those who will respond from those who will not. In many patients there will be no improvement, or may even by a worsening of the condition due to secondary complications or emotional stresses.

It is known that asthmatics who had eczema in infancy tend to have more severe asthma than other children and that seasonal asthma is more easily controlled than all year round asthma (perennial asthma). Fifty per cent of all allergic children, regardless of initial manifestations, will have asthma at some time during their lifetime.

## BRONCHITIS

Bronchitis of long duration may become one of the most serious problems in childhood. Usually the cough is accompanied by production of sputum, depending on the site and severity of the inflammation. The clinical picture of bronchitis is one of progressively severe attacks of bronchial coughing, with increasing production of secretions. Associated symptoms are lack of weight gain and fever, causing frequent absence from school. Chest X-rays usually show some increase in bronchovascular markings and frequently a sinus infection may be present.

The removal of all bronchial irritants from the inspired air is of great importance in treatment. Any type of dust or air pollution serves as an irritant in chronic bronchitis. This does not necessarily represent a true allergy, but rather a non-specific stimulus to mucus formation. Some of the chief offenders are tobacco smoke, dust and smog. A change in climate is of much less importance than the avoidance of irritants in the inspired air. The intermittent use of antibiotics may be sufficient to overcome a specific bout of bronchitis. However, it may be necessary to continue more prolonged use of antibiotics for the best results. Frequently gamma globulin levels may be low in these patients. Drugs that produce transient dilatation of the bronchi and reduce airway resistance are useful. Frequently, measurements of the vital capacity and rate of expiratory flow, before and after administration of a bronchodilator drug, are helpful in indicating the results of such therapy. Intensive treatment may be indicated during the acute or severe obstructive phase. Bronchial hygiene is very important to keep the respiratory system cleaned out. Potassium iodide or other expectorants may be helpful in reducing the viscosity of the sputum. Some of the mucolytic agents may be of help in thinning the secretions.

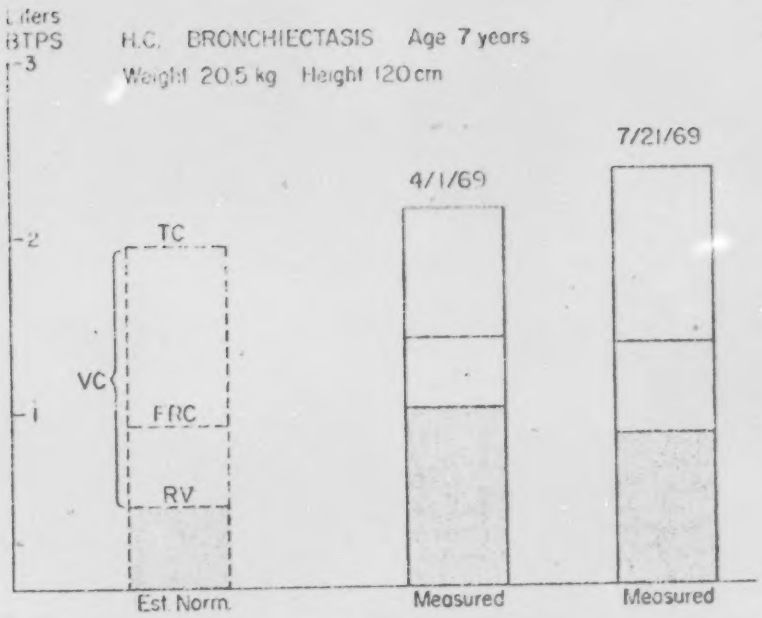
"Chronic asthmatic bronchitis" is a commonly used term referring to patients with recurrent or chronic bronchial infection associated with bronchospasm and wheezing.

## BRONCHIECTASIS

Several conditions may lead to bronchiectasis in children. Chronic cough and chronic bronchitis may be predisposing factors. Other conditions which may precede bronchiectasis are pneumonia, whooping cough and collapse of the lungs. The infection in bronchiectasis is more extensive than in bronchitis, with ulceration or breaking down of the bronchial walls, affecting the elastic, bronchial tissue and later the cartilage. Scarring may occur later in the disease process along with permanent collapse of the air spaces in some areas and there may be emphysematous changes in others. Dilatation of the bronchi is the most common type of bronchiectasis in children.

The clinical features of bronchiectasis are usually bouts of cough, with or without sputum, as the sputum may often be swallowed. Occasionally, the child may spit up some blood and there may be associated asthmatic symptoms. Most children are under-weight; many have chest deformities. There may be clubbing of the fingers, and an elevation of temperature. Sinusitis may be frequently associated with bronchiectasis. Chest x-rays usually show considerable increase in the bronchial markings. Bronchograms, which are done by instilling radiopaque liquids into the bronchial tubes and then taking x-rays, frequently show cylindrical and saccular areas in the lower lobes. Physiologic difficulties may be related to the severity of the disease process. The respiratory rate may be increased; there may be moderate obstructive impairment, decreased expiratory effort, and disturbance in ventilatory efficiency.

The prognosis, or expected course of the condition, is more severe in bronchiectasis than in bronchitis, and therefore warrants intensive attention to bronchial hygiene, including combatting infection when this is present, as well as maintaining clear airways and promoting bronchial drainage. If the diseased portion of the lungs is severely involved, then surgical excision may be warranted in some cases. However, physiologic medical therapy should be given adequate trial first.



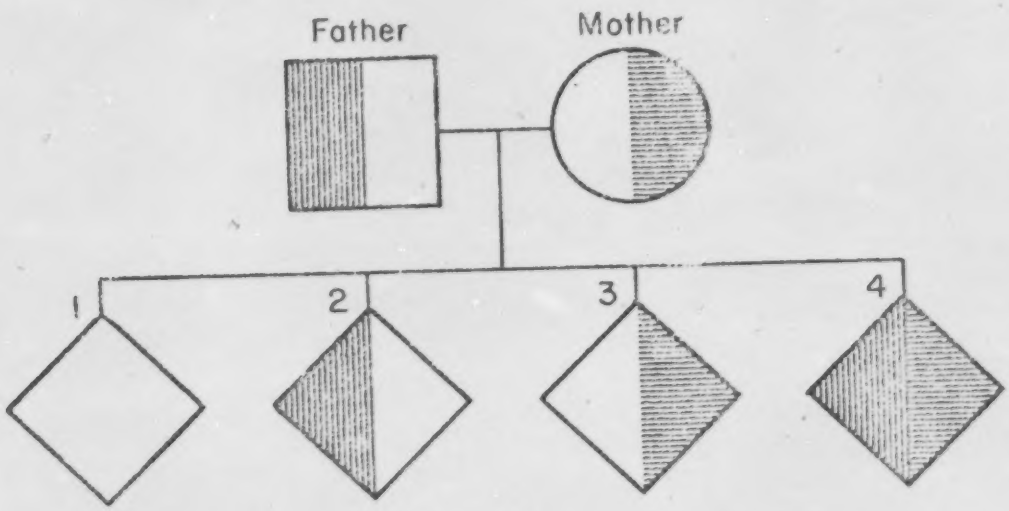

| | | | |
|---|---|---|---|
| PEF | 3.58 | 2.20 | 2.21 |
| MMEF | 1.60 | 0.59 | 0.44 |
| MBC | 52 | 30(58%) | 35(64%) |
| RV/TC | 0.20-0.25 | 0.47 | 0.36 |
| CLEAR EQUIV | 8-10 | 19.9 | 13.1 |

Improved pulmonary function in 7-year old bronchiectasis case following physiologic medical therapy.

# CYSTIC FIBROSIS

Cystic fibrosis is a congenital defect, or an inherited condition. It is not a contagious disease and cannot be transferred from one child to another. Both parents must carry the genetic trait. (See Genetic Chart below.) This is said to be a Mendelian recessive genetic trait present in one in 20 individuals. The odds of two such persons marrying is one in 400. One out of 4 of their children will inherit the cystic fibrosis gene from both parents and be a cystic fibrosis patient. Two may inherit the gene from only one parent and be carriers, and one child may be normal. Both sexes are affected equally. The age of the parents has no influence on the incidence, nor does the birth order of the child.

## GENETICS OF CYSTIC FIBROSIS




Cystic fibrosis is believed to be caused by the lack of, or insufficiency of some vital chemical substance, possibly an enzyme or hormone, which is essential to normal functioning of the sweat, mucous and other glands of external secretion. This basic bio-chemical defect is produced by the abnormal gene and remains unknown today. Normally the mucus secreted by the lining membranes of the organs is thin, clear and slippery. The mucus produced in the cystic fibrosis patient is thick and sticky, may obstruct the intestines, block the ducts of the pancreas and the liver, and plug up the airways in the lungs.

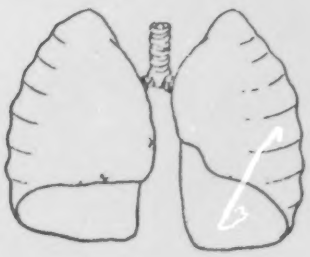
The clinical manifestations can be divided according to the various systems affected:

Sweating and Heat Prostration - Among the non-mucus producing glands of the endocrine system which are affected are the sweat glands, the tear glands, and the salivary system. In the sweat glands, the absence or deficiency of some unknown substance in the body tissue produces malfunctioning of the sweat glands, resulting in excessive sweating plus an inability to control the amount of salt in the sweat. This may lead to heat prostration. Likewise, there is an increase in the chlorides or salt in the tears. In the salivary glands there is an inability to control the loss of salt in the secretions resulting in a higher salt content than in the normal salivary secretions; these glands may be enlarged.

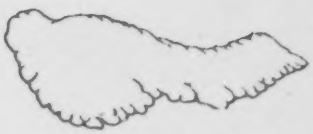
Chronic Lung Disease - In the lungs the abnormal mucus obstructs the air ducts, creating conditions which make the lungs susceptible to infection, and leading to chronic bronchitis, bronchopneumonia and emphysema. Pulmonary symptoms consist of fits of coughing frequently quite prolonged, which may cause vomiting and interfere with sleep. The lack of oxygen weakens the child and he may have rapid and shallow breathing. It is difficult to get enough oxygen for even the smallest physical effort. Therefore, he may be unable to run and play with other children, and may be frequently confined to indoors. He may develop a pigeon-like breast configuration; there may be a bluish color to his lips and nails due to cyanosis, and clubbing of the fingers and toes may occur due to inadequate circulation.

## THE MAIN CLINICAL FEATURES OF CYSTIC FIBROSIS

Sweating and heat prostration



Chronic lung disease



Pancreatic insufficiency

Pancreatic Insufficiency - The earliest clinical manifestation to be recognized was that due to pancreatic insufficiency, which resulted in chronic diarrhea, with large bulky, greasy and foul-smelling stools. Despite a voracious appetite, the patient fails to gain and may even lose weight. Distention of the abdomen may occur and limitation of subcutaneous tissues may give the appearance of thin arms and legs and thin buttocks. Rectal prolapse may occur. Occasionally in infancy, there may be intestinal obstruction (called meconium ileus). Usually these children are of small stature, non-athletic, quite intelligent and realistic and are quite mature emotionally.

## EMPHYSEMA

Secondary emphysema afflicts many children and results from a chronic respiratory disease such as asthma, bronchiectasis or cystic fibrosis. Primary emphysema occurs only in adults. Emphysema does not refer to a particular disease as such, rather it refers to a condition which occurs where there is long standing obstruction and hyperaeration leading to destruction of tissues. Once tissue is destroyed it cannot be replaced, hence the process of emphysema is irreversible. We believe that "pre-emphysema" (that is, obstruction and hyperaeration without destruction) occurs frequently in children and can be diagnosed at this early stage and effectively treated before irreversible destruction occurs. Pre-emphysema is seen in many asthmatic children, and in some with bronchiectasis and bronchitis.

Clinically, in the pre-emphysematous child there is usually some shortness of breath when the child exerts himself and oftentimes a history of cough. There is considerable interference with the movement of air out of the lungs and many times breathing is accompanied by wheezing. Physically the child with a pre-emphysematous condition is usually smaller in stature and less well developed than his peers. Oftentimes a child with this condition has a bulging or barrel chest appearance accompanied by a rounding of the shoulders with an increase in A-P diameter of the chest. Frequently in the earlier stages, there may simply be an increase in the aeration at the bases of the thorax. Thoracic measurements may be helpful; these consist of the following measurements: (1) from the tip of the xiphoid process to a line dissecting the lower thoracic cage; (2) and (3) from the left and right nipples respectively to the lower thoracic cage; (4) the circumference at the nipple line and (5) the A-P diameter. Preliminary studies indicate that such measurements may be helpful in early diagnosis of the reversible emphysema process. It is important to note evidence of expiratory distress as well as the color, the vigor, the alertness and fatigue of the individual. Frequently, sounds of the breath may be diminished or there may be numerous expiratory wheezes throughout. The bases of the lungs may be hyper-resonant; there may be scattered areas of increased tactile fremitus. Generally he tires quickly and may occasionally turn blue with extreme exertion.

X-Rays of child with emphysema showing barrel chest with overdistention and increased A-P diameter.

SECTION III ACUTE RESPIRATORY EMERGENCIES

Movies

Physiology of Infant Resuscitation

Recognition and Management of Respiratory Acidosis

ACUTE RESPIRATORY FAILURE

ACUTE MEDICAL EMERGENCY

ARTIFICIAL VENTILATION AND RESPIRATOR CARE

POST-SURGICAL INHALATION THERAPY

# PHYSIOLOGY OF INFANT RESUSCITATION*

Roy F. Goddard, M. D.

A fourteen minute 16 mm. color sound film, which presents research studies on the mechanical and physical forces required to expand the lungs of newborns. In addition, studies on the mechanics of breathing are reviewed, and the clinical application of these research studies is summarized.

Questions:

1. What pressures are required to mechanically-physically expand the unexpanded lungs of a newborn infant who has not breathed on his own?

2. Over what period of time can such pressures be given successfully?

3. Should any difference between inspiratory and expiratory phases by made with giving artificial ventilation to a newborn, and if so, why?

4. What is the (a) tidal volume, and (b) compliance of a full term newborn? Of a premie?

5. By what methods of artificial ventilation may one achieve successful resuscitation of the newborn?

*Comments by Dr. Goddard.

## RECOGNITION AND MANAGEMENT OF RESPIRATORY ACIDOSIS*

Reginald H. Smart, M. D., Hurley L. Motley, M. D., and Joseph F. Boyle, M. D.

A 29 minute 16 mm black and white sound film, which presents a case of respiratory acidosis. The importance of early recognition and correct methods of treatment are stressed. Various techniques for forced breathing are demonstrated and discussed and possible pitfalls explored.

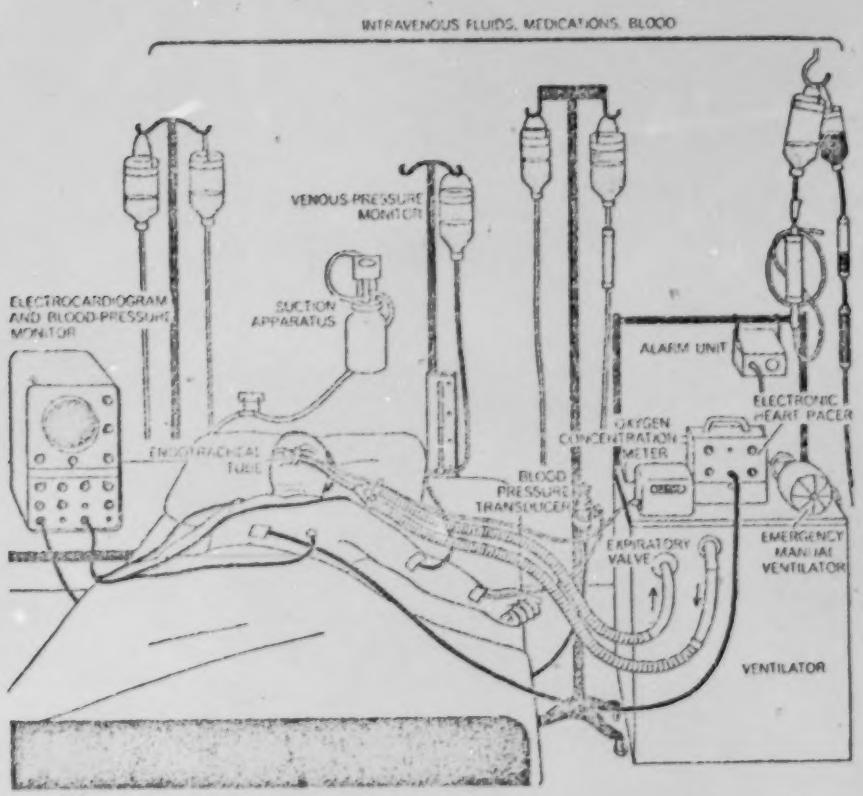
*Comments by Dr. Mary Mostyn.

## ACUTE RESPIRATORY FAILURE

The patient with chronic pulmonary disease is faced constantly with airway obstruction. This has been classified according to etiological factors, site, and physiological types on several pages of Appendix D.

If airway obstruction persists the patient then progresses to alveolar hypoventilation, with resulting hypercapnia and hypoxemia which may lead to death, as depicted in the charts in Appendix D. In the acute situation one must vigorously treat the airway obstruction, respiratory failure and insufficiency, as outlined in Appendix D, to interrupt impending fatality.

Following recovery from acute pulmonary insufficiency episodes, continuous concentrated attention and understanding of the clinical-physiological-pathological correlations of chronic pulmonary disease entities will lead to reversibility in many instances and to good prophylactic medicine in others. Early recognition and vigorous treatment are mandatory in the management of these forty-eight per cent of chronic conditions in our young patients.




Multi-Therapy Treatment of Patient with Acute Respiratory Insufficiency

41

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Goddard, R. F. "Bronchopulmonary Diseases in Infants and Children; The Physiologic, Pathologic and Clinical Relationships", Chapter 47, page 724, Clinical Cardiopulmonary Physiology, Grune and Stratton, New York, 1960.

Goddard, R. F., "Pre-Emphysema in Children, Its Recognition and Treatment", Ann. Allergy 19:1125, 1961.

# RESPIRATORY FAILURE

Mary Mostyn, M. D.

1. Causes and Definitions

2. Pathology

3. Physiology

4. Recognition of Respiratory Failure

5. Evaluation of Respiratory Failure

6. Treatment of Respiratory Failure, including principles of correction of physiological abnormalities.

# STATUS ASTHMATICUS

E. M. Mostyn, M. D.

Status asthmaticus is that state of asthma which does not respond to usual medical management. It is a major medical emergency.

Airways are narrowed and airway resistance is increased leading to gross inequality between the ventilation and perfusion with resultant early hypoxia and later hypercapnoea and acidosis.

Therapy must be immediate, by adequate intravenous hydration, oxygenation, use of steroids and antibiotics. Serial evaluation of glood gases is necessary and at the signs of increasing hypercapnoea endotracheal intubation and assisted ventilation may be necessary. The dangers of injudicious use of Isuprel and Aminophyllin are discussed and the value of bicarbonate and THAM in the treatment of severe status is considered.

References:

1. Pediatric Clinics of North America, February, 1969.

2. Rees, H. S., Miller, J. S., Donald, K. W., A Study of the Clinical Course and Arterial Blood Gas Tensions of Patients in STatus Asthmaticus, Quart. Journal Med. Vol. XXXVII No. 149, October, 1969.

3. Sykes, M. K., McNicol, M. W. and Campbell, E. J. M., Respiratory Failure, Pub. 1969.

# ACUTE MEDICAL RESPIRATORY EMERGENCIES

Robert Intress, M. D.

I. Definitions

"Acute" means severe, rapidly rising to a peak.

"Medical" generally refers to treatment consisting of drugs, physical measures and non-surgical methods.

II. Classification of Respiratory Emergencies

A. Anatomic - Physiologic

1. Central nervous system
2. Upper airway
3. Lower airway
4. Transport system
5. Tidal volume

B. Some Respiratory Emergencies

1. Inhalation of Noxious Fumes

a. Smoke: $CO + CO_2$

b. CO (automobile)

c. Industrial gases: "Freon", Ammonia, Chlorine, etc.

d. Insecticide and farm sprays

e. Paint sprays

f. War gases

g. Others

C. Drug overdose

1. Narcotics
2. Barbiturates
3. Alcohol
4. Tranquilizers

D. Asthma ("Status asthmaticus")

E. Foreign bodies in tracheobronchial tree

F. Pulmonary edema

G. Inflammation of tracheobronchial tree

H. Caisson's disease ("Bends") Scuba diving

I. Miscellaneous

1. C. V. Accident ("Stroke")

2. Tetanus

3. Poliomyelitis

4. Status epilepticus

III Treatment

A. Airway (Open)

B. Breathing (tidal volume)

C. Circulation (adequate BP and perfusion)

# MECHANICAL VENTILATION OF THE LUNGS

John Birch, M. D.

Short History

Physiological factors affecting volume exchange. Definition of compliance and airway resistance.

Indications for mechanical ventilation - disease states, anesthesia, etc.

Differences between controlled and spontaneous respiration - intrapulmonary, intrapleural pressures, etc.

Harmful effects of controlled ventilation - pressure effects on cardiac filling, interference with lung blood flow, damage to lungs, etc.

Minimizing harmful effects of controlled respiration - positive pressure should not be sustained longer than necessary to effect the desired volume exchange - inspiration should be shorter than expiration - mean intrapulmonary pressure should be low - expiratory resistance should be low.

Types of ventilation - pressure, volume and time parameters - advantages and disadvantages.

What gases to ventilate with and how much?

Problems of humidifications of gases.

Importance of serial blood gas measurements in monitoring long term ventilation.

Importance of direct expiratory spirometry.

Secretions, corss infection, damage to tracheal mucosa by inflated cuffs on tracheostomy and endo-tracheal tubes.

Concept of artificial ventilation reducing the work of breathing and thus oxygen consumption.

# POST-SURGICAL INHALATIONAL THERAPY

Arthur Roberts, M. D.

I Introduction

- A. Pre-existing Pulmonary Disease
- B. Pulmonary Impairment Due to the Surgery Itself

II Armamentarium

- A. "Stir-Up" Regime
- B. Nasal $O_2$
- C. Intermittent Positive Pressure Breathing
- D. Endotracheal Intubation
- E. Tracheostomy
- F. Nebulization, Hot or Cold
- G. Bronchodilators
- H. Enzymes

III Diagnostic Aids

- A. Clinical Estimation of Cyanosis
- B. Blood Gas Analyzer
- C. Monitoring Alveolar Gases

SECTION IV SUPPORTIVE THERAPY

PSYCHOLOGICAL ASPECTS

SOCIOLOGICAL ASPECTS

POSTURAL AND BREATHING EXERCISES

POSTURAL DRAINAGE AND HAND CLAPPING

# PSYCHOLOGICAL ASPECTS OF CHILDREN WITH CHRONIC PULMONARY DISEASE.

W. C. Leiding, Ph.D.
Clinical-Child Psychologist
Lovelace Clinic
Albuquerque, New Mexico

Investigative studies into the area of intellectual and emotional factors involved in chronic and fatal disease of children have been extensive for some time in many areas. Until recently very little has been done within the area of chronic pulmonary disease and particularly within the area of children with cystic fibrosis. With the intensive research which has been involved with investigating the physiological causes and, in turn, management of children with chronic pulmonary disease and cystic fibrosis, it would seem important, as well as necessary, to increase the knowledge and emphasis of the psychologic factors and the emotional overlay which is seen in many of the children afflicted with chronic pulmonary disease.

It can be readily understood that a child who is suffering from a chronic disease can and, in turn, does become psychologically vulnerable to emotionally traumatic crisis-type situations. However, a child can also adversely respond to such common like experiences as separation from the mother, threatened loss of dependency and corrective actions, which by normal children can be perceived as ordinary or tolerable but to these children are seen as intolerable. In order to insure position of security a child may, in turn, respond or react by psychosomatic-like reactions as a means of a self-protective defense mechanism.

Various problems confronting the parents of children with chronic disease have been described which, in turn, makes them more responsive to any psychologic overlay or psychologic symptomatology that a child may manifest. Feelings of guilt and inadequacy, excessive anxiety or over-compensation for negative and/or rejective feelings can lead to over-protection and, in turn, indulgence of the child. The whole area of discipline is a particular source of anxiety and uncertainty and, in turn, guilt. Hence, because of this, parents often find themselves in situations where they are unable to carry out the every day training measures which they might use quite comfortably with normal and healthy children. The basic fundamental question is whether a particular mother-child relationship can lead to psychologic symptomatology or whether, as a result of a chronic illness, this, in turn, structures a specific type of mother-child relationship which then leads to psychologic symptomatology and overlay.

As more studies unfold within this area a very salient fact seems to emerge, namely that in understanding and management of a child with chronic pulmonary disease, one must consider the child in its totality, psychologically as well as physiologically, as well as to consider the interactions between child and parent and parent and child and the whole family unit.

References:

Psychological Characteristics of Children with Cystic Fibrosis - Alexander Spock, M. D., Donald J. Steadman, Ph.D., - North Carolina Medical Journal - Vol. 27, No. 9, September, 1966.

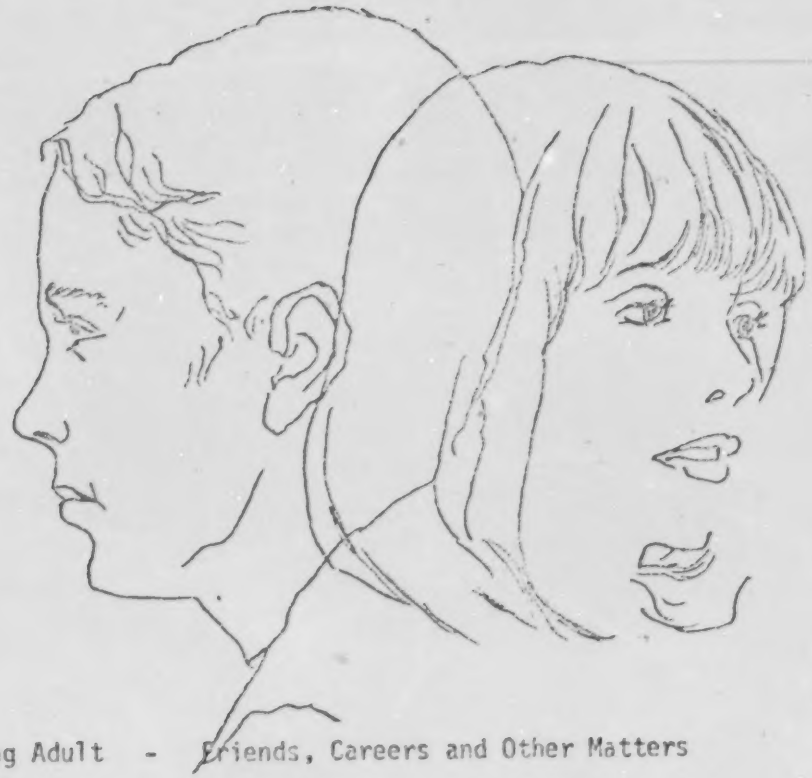
The Asthmatic Child: Psychosomatic Approach to Problems and Treatment - Harper and Rowe - 1963.

LIVING

WITH

CYSTIC

FIBROSIS*



A Guide For The Young Adult - Friends, Careers and Other Matters

"The life situation as a whole" is essentially the question with which the young adult or teenager with Cystic Fibrosis is likely to be most concerned. Physical management of the condition itself may call for a fresh approach when, for example, the older patient goes away to school. Beyond this, the problems everyone faces on growing up and becoming more independent - educational choices, establishment of mature relationships, adjustment to new environments, decisions concerning jobs and even marriage - may make special demands on the person with a background of cystic fibrosis.

One girl, a freshman in college, has asked: "Shall I tell my friends I have cystic fibrosis? . . . There can be no single, all-purpose answer to this or other such questions. What you feel free to tell your friends depends a great deal on the nature of the friendship.

Once cystic fibrosis has been mentioned, it is important to let people know that it is not contagious. Whey they understand that your coughing up of mucus presents no threat to them and is beneficial to you, they will lose much of the uneasiness they may have felt about it. . . .

"Shall I tell? poses a real dilemma in connection with employment. One new college graduate, a chemistry major, obtained his first job in the laboratory of an industrial plant, only to have it threatened when the company doctor learned he had cystic fibrosis. A waiver of his employee insurance enabled him to continue. . . . Lack of knowledge often is associated with lack of understanding and with fear. Your physicial usually will be glad to write to or talk with your proposed employer about you and cystic fibrosis.

*Booklet can be obtained from National Cystic Fibrosis Research Foundation 202 East 44th Street, New York, New York. 10017

# SOCIAL ASPECTS OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE

C. William Parker

The basic functions of the family in relationship to the larger society are socialization and mediation. Socialization refers to the process of preparing a child for his adult roles. Mediation refers to the efforts of all members of the family to adjust and conform to changing social demands. The basic question is whether and to what extent these functions are affected or inhibited by chronic respiratory diseases in children or adults.

There is much that the nurse, inhalation therapist, physical therapist, social worker, physician and others can do to help the family in performing these functions. Interest and emotional support is expected of all medical personnel. Excessive demands of time, money and inconvenience should be avoided. Most importantly, every member of the team should respond to appeals for help from the family members and make the proper person aware of the need. Many public and private agencies are available to help the family.

The full picture of the emotional aspects of chronic disease cannot always be described adequately in social terms. Crisis and trauma, as well as long term involvement with a disease, can make a child unable to mature sufficiently to accept adult roles. Since discipline and education are such important aspects of socialization in the healthy child, they receive special significance with a child suffering from a chronic respiratory condition. Guilt, feelings of inadequacy, resentment and rejection of the child with resultant guilt and anxiety, tend in many cases to make the parents more permissive than they would normally be. Because they feel the child is "vulnerable" the parents may become quite overprotective. Dependancy and retarded emotional growth is the frequent result.

The older person faces many demands from all sides -- family, government, business and others. Special efforts should be made to aid the adolescent and young adult who is suffering from a chronic respiratory disease to make the necessary life adjustment and accept normalized roles. A recent study has shown that the adolescent person who has cystic fibrosis tends to have a lower estimation of himself (in social, physical, emotional, and vocational terms) than his physicians, social worker or parents. There is evidence that a person who has cystic fibrosis can function well on the job or in school. It is clear from preliminary investigations, however, that much more is needed in the way of psychological and/or vocational counseling.

Anderson breaks the social work problems of families with cystic fibrosis children into three areas: 1. Financial 2. Success of treatment, and 3. Emotional and family integration problems related to the genetic nature of the disease. Research is being conducted in all of these areas. At present, the Pediatric Pulmonary Center has a stable population of about 40 families. About 10 per cent each are in the poverty area (below $3,000 income) and in the upper area (above $12,000).

At present New Mexico law does not include children with respiratory diseases under the Crippled Children's Service. It is frequently difficult for a person with chronic respiratory disease to obtain medical or life insurance. Special diet, medications, frequent health care visits, and special equipment pose special

financial burdens. The Turk study showed that many families with cystic fibrosis children are forced to give up vacations, some forms of entertainment, various household conveniences, and a general increase in standard of living.

The basic demand made upon the physician is that of successful treatment. Because so many family problems are centered around the child, it is imperative that the physician reduce the burden of the disease as a means of reducing the overall strain on the family. For this reason families of children with serious respiratory conditions on the whole visit many physicians before finding one who can deal effectively with the physical as well as the psychological and social problems. This search can in turn produce more anxiety and potential threat to family and child. As symptoms become less threatening and restrictive to parent and child, the process of family reintegration, reduction of anxiety, socialization and mediation can take place.

A family crisis can occur during the pre-diagnostic stage; with the diagnosis of cystic fibrosis or other life threatening respiratory disease; with frequent hospitalizations of a child in acute distress; or more directly because of the genetic aspects of cystic fibrosis. Studies have shown that internal crisis (chronic disease, mental illness, etc.) is more disruptive of family integration than external crisis (fire, flood, etc.); that an internal crisis takes longer to resolve and tends to lead to lower family integration in the final outcome. Relative to this the Turk study showed a general lack of discussion about the disease in families with cystic fibrosis children. Short term family therapy is indicated in many cases.

It is imperative that as more children who have cystic fibrosis and other serious respiratory diseases are reaching adulthood that the development and proper use of social, psychological, and vocational counseling resources take place. Environmental manipulation and parental guidance are the best ways of insuring healthy emotional development of the child in the home. The adolescent or young adult should be given special guidance in matters of life adjustment, marriage and occupation. the majority of adolescent patients could benefit from the services of a vocational psychologist or the state vocational rehabilitation agency. It is the responsibility of every health professional to be aware of such resources. Further, it is our duty to fight for social changes which will permit the family to better adapt to the strain of a chronic respiratory condition.

The family is the least organized and most flexible social insititution. It is often forced to adapt to demands of government, business and the health system. The strains which these forced adaptations pose upon the family must be balanced by the love, security and emotional support which a healthy family can give. The health team can provide for medical and emotional care, but it must also be aware of the great contribution to social change that it can make.

References: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2. Vocational and Life Adjustment Problems of Young Adults with Cystic Fibrosis: A Pilot Study. Project RD-2777-M-69, NCFRF, N.Y., 1969.

3. Dorothy H. Anderson, "Cystic Fibrosis and Family Stress", Children 7:1, January, 1960, pp 1-4.

4. Juanita Turk, "Impact of Cystic Fibrosis on Family Functioning" Peds., July, 1964, pp. 67-71.

AGENCIES INHALATION THERAPISTS MAY DESIRE TO CONTACT

American Red Cross

Bernalillo County Health Department (and others statewide)

Bernalillo County Medical Center

Carrie Tingley Hospital for Crippled Children

Easter Seal Society for Crippled Children and Adults

Los Lunas Medical Center (for retarded children)

N. M. Chapter, Muscular Dystrophy Association

N. M. Cystic Fibrosis Research Association

New Mexico Department of Health and Social Services

New Mexico Tuberculosis and Respiratory Disease Association

N. M. Division of Vocational Rehabilitation

United Cerebral Palsy of Albuquerque

U. S. Public Health Service, Division of Indian Health

U. S. Army, Air Force (Champus-military health insurance)

Veteran's Administration

For further information, specific information about the above Albuquerque agencies, questions, or problems, please contact Nancy Barfield at the Community Council of Albuquerque. (Phone 247-3671). State agencies and others can usually by contacted through state or local listings.

# POSTURAL AND BREATHING EXERCISES

A. R. Becker, R. P. T.

## POSTURE

Children with respiratory difficulty tend to develop a defective posture and loss of the mobility of the thorax, most of which are reversible. The most common defects are:

1. Forward thrust of the head.
2. Round shoulders and barrel chest.
3. Kyphosis of the thorax.
4. Compensative lordosis.
5. Scoliosis.

Evaluation of posture may be by the use of a posture grid, plumb line, or experienced clinician observing the child during the general examination. Roentgenographic studies may be required. The exercises prescribed must have the following objectives in view before erect standing posture can be corrected.

1. Relaxation.
2. Stretching the tight structures.
3. Strengthening the stretched structures.

The physician should indicate the defects to be corrected and the next recheck date to enable the therapist to outline a progressive program with realistic goals. The exercise routines should be carried out at least two times daily.

## BREATHING EXERCISES

Breathing patterns differ due to the increase in lung volume caused by a flattened, less mobile diaphragm, which remains in the inspiratory position. With a diaphragm less active to ventilate; the patient uses his upper intercostal muscles and the accessory muscles of the neck and shoulders to pull the thorax upward and forward. This disordered breathing pattern results in a high energy cost of breathing, dyspnea and fatigue.

Breathing exercises are taught to the patient to strengthen the diaphragm function so that it may become more active. This will result in improved alveolar ventilation, a decrease in the work of breathing and will lessen the patient's natural desire to relieve his shortness of breath by hurried gasping inspiration which overinflates the lungs and traps still more air, and will also relieve his anxiety.

Aims of exercises:

1. To develop a new pattern of breathing.
2. To develop voluntary control of expiration.
3. To increase efficiency of muscles of expiration.
4. To control inspiration by "breathing" in a relaxed and passive manner with the control of the diaphragm only.
5. To coordinate the new breathing pattern with activities of daily living.
6. To reduce the thoracic cage and lungs to normal size.

Breathing routines should be carried out two times a day.

# POSTURAL DRAINAGE AND HAND CLAPPING

A. R. Becker, R. P. T.

Segmental postural drainage is an important and effective method of assisting the normal mechanism of the tracheobronchial tree of the elimination of excessive secretions. To accomplish this the patient is placed in a sequence of positions, each designed to drain a particular one of 18 segmental bronchi. Twelve positions have been organized into a simplified sequence which can be remembered easily by professional or lay individuals who may be called on to care for the patient. Each position allows the placement of the related segmental bronchus in a vertical orientation to allow mucus to flow downward. Each position is maintained for 4 to 6 minutes or longer as indicated.

To assist the movement of the secretions, the chest wall is vibrated by one of two techniques:

Hand Clapping: Using a cupped hand, with the thumb firmly against the index finger will provide a cushion of air between the hand and the chest. This makes the procedure more comfortable for the patient. The clapping should be carried out with a rhythm and with relaxed arms, since this is much less tiring for the therapist. Clapping is to continue in one position for a period of two minutes.

Vibration: Is produced by placing the hands firmly on the chest wall and tensing the muscles of the arm and shoulder until vibration occurs while pressing inward on the chest wall. This is applied during Expiratory phase of breathing only. This and excellent mechanical devices have been developed to substitute for the manual hand clapping and vibration. They are being evaluated as to their effectiveness and safety.

Frequency of Treatment:

1. Two to four times a day. The two most important times are immediately upon arising and just prior to going to bed. The remaining two treatments would be before lunch and mid-afternoon. Treatment should not be attempted any sooner than one hour after a meal.

2. If treatment is given in conjunction with inhalation therapy, it usually follows, although it can precede inhalation therapy.

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SECTION V INHALATION THERAPY

PRINCIPLES OF INHALATION THERAPY

INFANT RESUSCITATION

INHALATION THERAPY IN THE NEWBORN NURSERY

CHILDREN'S HOSPITAL SERVICES

AEROSOLS (SEE APPENDIX E)

INTERMITTENT POSITIVE PRESSURE BREATHING (SEE APPENDIX E)

EMERGENCY INHALATION THERAPY

OUTPATIENT AND PPC TECHNIQUES

HOME THERAPY

CLEANING, STERILIZATION, MAINTENANCE AND SAFE USE OF INHALATION THERAPY EQUIPMENT (SEE APPENDIX E)

INHALATION THERAPY REFERENCES

GROUP INHALATION THERAPY SESSIONS AND DEMONSTRATIONS

LIST OF EQUIPMENT (SEE APPENDIX E)

ORGANIZATION OF AN INHALATION THERAPY DEPARTMENT (APPENDIX E)

# THE PRINCIPLES OF INHALATION THERAPY

Roy F. Goddard, M. D.

The success of an inhalation therapy program or department rests upon three main factors: the proper prerequisites in organizing and carrying on such a program, an efficient method of ordering and carrying out inhalation therapy, and achieving major objectives of inhalation therapy in the treating of respiratory conditions in children and young adults.

## Prerequisites

We can sum up the prerequisites briefly:

1. Interest of physicians and para-medical personnel.
2. Awareness of need by hospital administration.
3. Division of inhalation therapy department into specialized sections.
4. Highly motivated and qualified director.
5. Well-trained chief of technical section.
6. Continuing in-training and post-graduate education programs.

## Orders

All therapy should be ordered by the physician, with explicit instructions as to how it should be given, and no inhalation therapy should ever be carried out without the proper order and requisition.

## Major Objectives of Inhalation Therapy

The main objectives of all inhalation therapy should include:

1. Bronchial Hygiene
   a. Bronchodilatation
   b. Liquefaction of secretions
   c. Overcoming irritation and edema
   d. Counteracting infection
2. Humidification
3. Oxygenation
4. Ventilation
5. Positive Pressure (IPPB)
6. Resuscitation
7. Aerosol mist therapy

## Factors Influencing Administration of Inhalation Therapy to Infants and Children

The main factors which influence the administration of inhalation therapy to infants and children are four in number: the size of the individual, cooperativeness, the pediatric disease entities peculiar to infants and children, and the influence of durgs, trauma, and foreign bodies on the child's ventilation.

Size

It is well known that a wide variation in body size exists in pediatric age groups, ranging from the newborn to the adolescent or young adult. Similar to the maturity of the body size may be the maturity of the respiratory system. The size of the respiratory passageways and the maturity of the lungs obviously influence the administration of inhalation therapy, especially with respect to the introduction of tubes into the respiratory orifices. The smallness of the structures and the range in the size of respiratory structure and total body size, necessitates the development and use of small equipment designed specifically for each age range and size.

Cooperativeness

It is readily apparent that inhalation therapy to an infant or small child is more difficult to administer than to the older child. It has often been said that "a great deal of patience is required in treating small patients." Thus, the inhalation therapist or individual who is administering the inhalation therapy to the infant or child must be schooled in these problems of size and cooperativeness and be prepared to carry out his duties accordingly.

Pediatric Disease Entities

There are specific disease entities or conditions in pediatrics which do not occur in the older age groups (see table below). The sites of affliction of some respiratory conditions peculiar to the younger pediatric age are also shown.

*RESPIRATORY CONDITIONS MOST FREQUENTLY ENCOUNTERED IN PEDIATRIC AGE GROUPS*

| Group | Respiratory Condition |
|---|---|
| Newborn | Abnormal pulmonary ventilation (atelectasis, hyaline membrane, aspiration, unexpanded lungs) |
| | Anoxia |
| | Congenital anomalies |
| Infant | Atelectasis (infectious, mechanical) |
| | Bronchiolitis |
| | Croup |
| | Congenital anomalies |
| | Pneumonia |
| Toddler | Asthma |
| | Croup |
| | Mucoviscidosis |
| | Pneumonia |
| School Child and Adolescent | Asthma |
| | Bronchitis |
| | Bronchiectasis |
| | Pre-Emphysema |
| | Poliomyelitis |

It is important to realize that certain areas of the respiratory tract may be affected alone, and thus indicate a specific type of inhalation therapy for that particular area. For example, croup affects the upper respiratory tract primarily, and may require one type of inhalation therapy, while bronchiolitis affects the lower respiratory bronchioles, and may require another type of inhalation therapy.

Croup causes primarily an upper respiratory obstruction which occurs during inspiration and necessitates getting air-oxygen through the upper obstructed airway down to the lower respiratory system. In contrast, bronchiolitis is primarily a lower respiratory obstructive phenomenon requiring a different approach to insure adequate ventilation during the entire respiratory cycle or breath.

Pneumonia involves the alveolar air spaces and requires treatment and ventilation of these spaces, while asthma is primarily an obstructive expiratory problem, similar to that of acute bronchiolitis. The pathology seen in cystic fibrosis or mucoviscidosis is usually a combination of respiratory obstruction, with areas of collapse of the lungs, and many areas of infection. Poliomyelitis, now rarely seen in children, may combine obstruction with paralytic involvement, requiring muscular and ventilatory assistance.

Drugs, Trauma, Foreign Bodies or Agents

The practicing physician must be aware of the influence of drugs on the respiratory system, especially with reference to depression of respiration, and he must also be aware of dosages which can be tolerated by the infant or child. The treatment of certain respiratory conditions, such as asthma, necessitates avoidance of drugs which may cause respiratory depression, and may require the intelligent use of bronchodilators in overcoming specific obstructive conditions. The physician and the inhalation therapist must realize that the moribund infant or young child may have taken a medication in excessive amounts, this being a known medication, or a medication unknown to the parent. Thus the inhalation therapist and physician may be treating a symptom rather than a known condition.

Infants or younger children who have suffered from trauma in the home, on the playground, in accidents, or from manhandling, either by other children or parents, constitute a significant problem in the inhalation therapy area in establishing proper ventilatory measures. It is of extreme importance here to have as complete a history as possible as well as confirmatory x-ray and other evidence before inhalation therapy is ordered. Again a symptom may be under treatment initially until the entire situation can be pieced together.

Frequently in the younger age group, foreign bodies are taken into the upper respiratory system and accidently become lodged in the upper respiratory system, the trachea or windpipe, or into the major bronchi, or even the bronchioles. (Examples of these include marbles, whistles, small plastic toys, watermelon seeds, pieces of coal, etc.). These foreign bodies cause a ball valve-like obstruction, with air trapping and whistling or wheezing. Obviously, the primary treatment is removal of the foreign body, but in the meantime the inhalation therapist may be called upon to assist in ventilation. Foreign agents or food may be aspirated during vomiting. Similarly, young children may drink kerosene, cleaning fluid, lighter fluid or other chemical agents, which are irritating, and if these are vomited up into the respiratory system, or regurgitated into the respiratory system, either by the patient himself or during gastric lavage, they will cause irritation to the respiratory tract with ensuing complications. The inhalation therapist should be prepared to assist in the ventilation and humidification of the respiratory system in many such situations.

Infants

Since this course primarily is concerned with children and young adults, we will only mention that inhalation therapy is an important adjunct in the management of infants with respiratory distress problems. In addition to humidification equipment for incubators, assisted ventilation may be life saving in many instances. Emergency resuscitation may be given by mouth-to-mouth methods or via the GBL (Goddard-Bennett-Lovelace) Infant Hand Resuscitator.

Children's Hospital Services

Mist Tents

Many children with severe respiratory distress, whether it be an upper obstructive type or lower obstructive and restrictive type of ventilatory impairment, may require an oxygen enriched atmosphere. The child with such respiratory obstructive processes as croup, bronchiolitis, pneumonia and atelectasis can be placed in a croup tent in which humidity, oxygen concentration and temperatures can be controlled. Additional medicaments may be aerosolized by using a separate nebulizer and incorporating them into the croup tent. The child's clinical improvement should be carefully observed, with observation of retractions, grunting, respirations, color, pulse, hydration, and temperature. Particular attention from the therapist or nurse should be devoted to: oxygen concentrations and flows, temperatures within the tent, ice levels if ice is being used to aid the cooling of the tent, proper working order of all nebulizers, attention to the level and contents of the nebulizers, plus keeping the canopy of the croup tent tucked in an securely as possible to prevent loss of oxygen and humidity and interference with temperature and air-oxygen circulation.

In the toddler or older child the patient should be placed in a taller tent or canopy which allows movement within the tent. In order to get sufficient humidity and mist it may be necessary to employ two medium sized compressed gas nebulizers (Mist-$O_2$-Gen, MG11C Model, droplet size 3.5 microns). When a greater output is desired, or after secretions have been loosened up by smaller droplet sizes, an ultrasonic nebulizer can be subsitutted as the source of mist for the same tent.

The older child may be housed in a standard oxygen tent which will usually suffice for milder cases of respiratory distress. In some instances it is beneficial and desirable to aerosolize medications within these tents. Most high humidity model oxygen tents will, of course, nebulize water to increase the relative humidity within the tent. Other medicaments can be nebulized in high humidity model tents also, unless specifically prohibited by the manufacturer. When other medications are nebulized in these tents special care should be taken after therapy has been discontinued, or during routine maintenance, to assure that the unit has been thoroughly cleaned. Older model oxygen tents not incorporating high humidity features can easily be turned into high humidity models by the addition of aerosol generators which attach to or hang in these tents. It is advisable to seek the manufacturer's advice before aerosolizing medications other than distilled water in older model oxygen tents. When using a standard "non-high humidity" oxygen tent to administer aerosols, the circulation should be set lower than usual to keep the exhaust vents from extracting the mist or aerosol before it has had a chance to be inspired by the patient. However, the circulation should always be maintained high enough to assure against carbon dioxide buildup in the canopy of the oxygen tent.

Concentrations of the atmosphere within the tent canopy should be analyzed at least every four hours, and whenever the tent has been opened for more than one minute.

Particular attention should be paid to the filters on the intake or exhaust vents of the oxygen tent to prevent clogging and thereby overheating of the tent's electrical and circulating system. The therapist should also note the temperature, condition of the canopy, relative humidity, flow and concentration of oxygen and general condition of the patient, as outlined previously in the croup tent section. A particular problem encountered with aerosol therapy in refrigerated oxygen tents is, of course, the temperature of the air within the tent itself, and the smaller amount of humidity that these cooler masses of air can carry, thus offering lesser amounts of humidity to the inspired air. It is suggested therefore, that the following is necessary to effective aerosol therapy in refrigerated oxygen tents:

1. Large volumes of aerosolized fog or mist of small micron sized particles,
2. Temperatures no lower than necessary to assure comfort to the patient, and
3. Adequate circulation to assure against $CO_2$ buildup, but not excessive enough to withdraw moisture from inspired air.

Other effective methods for the administration of oxygen therapy and aerosol therapy in children are with face masks and open top face tents. As a general rule, disposable and permanent (re-usable) face masks and face tents are of the following types: (1) Face piece only, (2) reservoir bag type, (3) partial rebreathing type, (4) open top face tents. Many other types of masks, which are not used too frequently, especially with children, are available such as meter masks, positive pressure (on exhalation) masks, nasal partial rebreathing masks and masks with exhalation flutter valves built in. Oxygen can be given via a nasal catheter or cannula with some success in older children.

Aerosols

An aerosol has been defined as a suspension of droplets of a liquid in a gas. The aerosol is produced by a fine stream of liquid being struck by a jet of gas or air of high velocity. The liquid is broken up into particles of varying sizes dependent on the velocity of the jet. The size of the droplet is important when one considers what area of the respiratory tract is to be treated, as hypothetically depicted on a previous illustration, the larger droplets are deposited on the surfaces of the upper respiratory passageways and only the smaller droplets reach the bronchioles and alveoli. If one contrasts the sites of droplet deposition with the sites of affliction of various respiratory conditions in children, then the importance of utilizing those devices which deliver the appropriate sized droplets becomes apparent.

Aerosols used in inhalation therapy are usually of five types: (1) bronchodilators; (2) antibiotics; (3) wetting agents or antifoam solutions; (4) digestive enzymes; and (5) diluent fluids. The most satisfactory bronchodilators used for children have been Bronkosol (isoetharine, phenylephrine, thenyldiamine) and Isuprel (isoproterenol). Vaponefrin and Miconefrin (especially purified racemic epinephrine hydrochloride solutions) have been used in some patients initially or partially non-responsive to Bronkosol or Isuprel. Among the antibiotics which have been used successfully are penicillin, streptomycin, erythromycin, novobiocin, oxytetracyline, and kanamycin. Alevaire has been used as a wetting agent to help in the reduction of surface tension and liquefaction and emulsification of mucus. Mucomyst, as well as the enzymatic agents, Tryptar and Pancreatic Dornase (Dornavac) are used sparingly, when indicated, for further liquefaction of thick, tenacious secretions in children with asthma, bronchiectasis and mucoviscidosis. Diluents are usually sterile water, saline or 5 to 10 per cent propylene glycol.

Intermittent Positive Pressure Breathing

In bronchopulmonary disease of children with features of obstruction and restriction, it is necessary to maintain clear airways, promote drainage, control infection, and prevent impending emphysema and cor pulmonale. Physiologic therapy includes respiratory exercises, if cooperation can be satisfactorily attained, and the use of intermittent positive pressure breathing treatments.

Children from 1 to 5 years of age use the Bennett IV-4P or IV-3C pressure breathing units, modified from the TV-2P adult model. These provide a greater flow, sensitivity, and less dead space in the connecting face-piece attachment. Slow, deep breathing is desirable in order to avoid hyperventilation.

As the child becomes adjusted to the positive pressure breathing techniques, an aerosol mixture can be introduced through the nebulizer. Initial pressures of 8 to 10 cm may be increased to 10 to 15 cm, depending on the age of the child and the response to treatment. Initial treatments range from five to ten minutes. Most routine treatments are of ten minutes' duration; occasionally some may be increased to twelve minutes.

The TV-2P Bennett therapy unit is used in children over the age of 6 years for giving inspiratory positive pressure breathing in asthma, chronic cough, bronchitis, bronchiectasis, and mucoviscidosis. The advantages of this type of therapy are: (1) it provides uniform alveolar aeration with improvement in blood gas exchange; (2) it overcomes spasm and promotes bronchial drainage with decrease in irritation and infection; (3) it provides breathing exercise with improvement in muscle tone and compliance. This is particularly helpful in many small children who cannot be taught breathing exercises.

The frequency of IPPB treatments in the hospital may range from one per day to as many as six per day. Usually, these treatments are at 10 cm positive water pressure for a period of 10 minutes. If enzymatic agents such as Tryptar, Pancreatic Dornase, or Mucomyst are used, their use is usually restricted to once daily, because these agents may cause some irritation and hypertrophy of the bronchial epithelium. With improvement of the disease process, the frequency of treatments is reduced.

Heated aerosols, cascade humidifiers, or ultrasonic nebulizers may be incorporated into IPPB machines to supplement therapy.

Certain cautions are advised. A small dead space can be provided by utilizing a small piece of rubber tubing connecting the face piece and the exhalation valve. The nurse or inhalation therapist stays with the child during treatment, placing a hand on the back of his head and a hand to seal the mask tightly, so that there is no leak at the upper area into the eyes or a leak downward in the chin area. The child is encouraged to stop and cough and get up secretions.

Frequently children with severe pulmonary disease, such as cystic fibrosis, may not be able to trip the valve on the regular machine, and therefore an automatic cycling attachment on the Bennett IV-1A respirator unit or a special attachment on the TV-2P model can be used. Suctioning facilities should always be available. The child should be allowed to proceed according to his response to the treatment being administered.

Well-trained nurses in the pediatric department or technicians from the inhalation therapy section can give these treatments and become proficient in the follow-up care of infants and children.

Post-Operative Inhalation Therapy and Ventilatory Assistance

Postoperative inhalation therapy in infants and children is coming into use more and more throughout the country. This may encompass placing a child of any age in an oxygen-enriched atmosphere with a fine mist to help in the prevention of postoperative ateiectasis and complications, and providing other assistance, such as intermittent positive pressure breathing.

Ventilatory assistance for polio or other muscular afflictions is rarely needed today. Occasionally, however, a tank respirator or a combined IPPB respirator unit is helpful in short term ventilation of infants and children with amyotonia congenita, traumatic injuries of the chest, or the rare case of anterior policmyelitis. Here, also the Engstrom respirator may be of help. Assisted ventilation may also be required in the management of acute respiratory insufficiencies and/or failure.

Emergency Inhalation Therapy

Inhalation therapy should be available in the emergency room and throughout the hospital for emergency situations. Equipment should include: that which can deliver oxygen alone; resuscitative devices; a combined respirator-positive pressure therapy unit; laryngoscopes; suction device; airways, and endotracheal tubes with connectors to the respirator for the anesthesiologists (or other physician's) use. Tracheotomy equipment is of prime importance and should be readily available to the physician during respiratory emergencies.

Many hospitals today have a sector set aside in their emergency center for cardio-respiratory emergencies. In addition, a special set of equipment is kept ready at all times in a portable cart with drawers for specific items. This cart can be taken rapidly to any part of the hospital. Some hospitals will page "Dr. Heart" whenever any patient in the hospital stops breathing or has cardiac arrest. The Inhalation Therapy Team and whatever physicians are in the hospital at the time respond immediately to the "Dr. Heart" call and its location.

Office and Outpatient Services

Inhalation therapy in the office and on an out-patient basis may include facilities for giving oxygen alone; a mixture of gases; aerosols via air compressors or oxygen, or together with positive pressure. Many physicians' offices and out-patient clinics and departments are now well equipped with intermittent positive pressure machines. This equipment is essentially the same as described in the earlier section for hospital use. It is neceesary that trained personnel be available to give inhalation therapy in the office, and frequently a special suite or room set aside for this type of therapy.

Where inhalation therapy is an integral part of a physician's office or the outpatient department or clinic, provisions should be made for emergency as well as routine inhalation therapy. In addition periodic subjective and objective evaluation of the patient's progress is imperative.

Frequently, children requiring week-end or uninterrupted IPPB or other inhalation therapy can be referred to the emergency room of the hospital or directly to the Inhalation Therapy Department for treatment. The physician desiring such treatment for his patient should send along specific written orders with the patient. We

have found a "treatment card" helpful for the patient to carry with him at all times. This is similar to a diabetic card.

Children who may require emergency resuscitation or ventilation either in the office, at home or school, on the playground, or in any emergency situation, can be ventilated by mouth-to-mouth resuscitation or with the aid of a simple portable "bag" type respirator.

Inhalation Therapy in the Home

Vaporizers

For many years, vaporizers have been used in the home to produce humidity and more specifically for the treatment of croup and other upper respiratory problems in children. Humidity has been defined as the amount of moisture, or water vapor, in the air. When the air has absorbed the maximum amount of moisture at given temperature and pressure, the air is "saturated". The term "relative" humidity refers to the actual amount of water in the saturation. The warmer the air, the more moisture it can hold. In today's modern centrally heated homes, the air in a confined space is heated, raising the moisture carrying potential of the air, which seeks out all available moisture from the environment and individuals living in the environment. It is imperative that moisture be replaced constantly in the healthy individual and becomes extremely important in the treatment of the individual with a dry, irritated, and afflicted respiratory tract. In such treatment the most satisfactory type of vaporizer is one that can run for eight hours or more and deliver a good moisture content (saturated) in the immediate vicinity of the infant or child. It is desirable that vaporizers which employ heat (usually from electricity) as the method of vaporization (the gaseous form assumed by a liquid particularly when heated) be firm and not easily tipped over, in order to minimize the danger of the child getting burned.

In more recent years, cold mist generators have been developed which produce drop-free vapor in sufficient quantity to raise humidity within the average room to a comfort zone of 40 to 50 per cent at around $72^{0}$ F. This overcomes the necessity of heating up the room more and further drying out the moisture or humidity of the house. The modern cold mist humidifier vaporizer is safe and practical for use in the home at the bedside or in any room. This has an 8 to 12 hour capacity (for overnight usage), and in many instances, cold mist has proven to be more beneficial than heated in the treatment of many upper respiratory disorders (colds, pharyngitis, laryngitis, and croup). Detergent-wetting agents can be added to distilled water for use with the cold mist humidifier vaporizer.

Aerosol Treatments

When a large amount of mist is required, and one that can be continued constantly for a period of several minutes, a device to deliver an aerosol with considerable force and continuity has proven very successful in the home. The usual aerosol agents can be administered by such devices. Such a home therapy unit produces a fine aerosol mist, which can be breathed into the respiratory system via a mask that has an inhalation and exhalation valve attached, so that only a small dead space exists.

The nebulizer is driven by an air compressor pump which can be placed on a table or floor. The entire unit can be placed in a container and becomes portable for use when visiting, traveling, and vacationing. The patient can occupy himself with

enjoyable activities, such as reading or watching television. Duration of treatment can be varied from 10 to 30 minutes, and medications ordered by the physician to fit the needs of the child. This simple aerosol therapy has become popular in the treatment of many children with chronic obstructive pulmonary conditions, including cystic fibrosis (mucoviscidosis).

Intermittent Positive Pressure

If intermittent positive pressure is desired with aerosol therapy it can be given in the home with the new Bennett Model AP-4 or AP-5. They are self contained, portable IPPB units, which compress room air - but can be used with supplemental oxygen delivered through the nebulizer. It offers the advantages of positive pressure breathing therapy, without high oxygen concentrations. (Without adding oxygen through the nebulizer, the AP-4 and AP-5 deliver concentrations of 21 per cent oxygen). The units can be plugged into standard 110 volt, 60 cycle, AC current or used from an auto 12 volt ignition system with the BEnnett LC-1 converter.

Tents and Night Therapy

Many allergic and asthmatic children have respiratory distress during the night. Various influencing factors are the position (flat) of the body during sleep with a tendency for secretions to puddle in the dependent lobes of the lungs, irritation from dry air in overheated bedrooms; and pollens coming in through the open windows during the various pollen seasons. Commercial filters, humidifiers, and purifiers have not been too successful in the alleviation of symptoms for these children.

When the child with respiratory irritation needs greater humidity during sleep, home tents can be used to provide the desired humidity. These can be devised by the parent, utilizing blankets and sheets in conjunction with heated or cold mist vaporizers. However, when obstructing secretions are constantly present in the lower respiratory tract (bronchioles and downward) - such as seen in children with mucoviscidosis, bronchiectasis, and severe asthma and bronchitis - a heavier fog or mist and smaller droplet size production are desirable. Such aerosol-mist environments can be readily achieved in the home with the use of two MGIIc (Mist-$O_2$-Gen) nebulizers placed in a simple plastic canopy and frame. This tent is part of the complete home inhalation therapy unit used in such cases, including aerosol treatment equipment, (nebulizers, heavy duty air compressor, canopy, tent frame, mask, and Y tubes). In selected cases ultrasonic nebulization may be substituted for the compressed gas nebulizers. Oxygen or other gases can be made available by commercial cylinders, if needed.

Cleaning, Sterilization, Maintenance and Safe Use of Equipment

Since it would be impractical to outline cleaning, maintenance and sterilization procedures for each piece of equipment used for inhalation therapy, the following brief generalized statements concerning cleaning, maintenance and sterilization are presented. They can be applied to almost all inhalation therapy equipment used in all areas of the hospital, at home, or in the office.

Cleaning

Articles to be cleaned should be disassembled as much as possible to eliminate blind openings. The article should be scrubbed with a good soap cleanser (such as Arex or other comparable cleanser) and rinsed thoroughly with water, after which it should then be carefully checked to see that no organic matter is still adhering to it. Jet orifices in nebulizers should be cleaned with a stillette and blown out

compressed air. Articles not properly cleaned cannot be adequately sterilized.

Sterilization

There are three methods of sterilization currently acceptable. These are described in detail in Reference No. 2.

Maintenance

The maintenance of the equipment used for inhalation therapy is usually very simple. Routine preventative maintenance can be carried out during the cleaning and sterilization of the equipment. When major repairs are needed, such as replacement of a blower motor or a valve in a respirator, the repairs should be done by a factory authorized repair company or individual, or be sent to the manufacturer (unless someone well qualified to repair inhalation therapy equipment is close at hand). A "quickie" or temporary repair is not worth the risk to the patient. Life saving equipment must be readily available and always in proper working order.

Safe Practices

Those who administer and handle oxygen and oxygen therapy apparatus must observe certain precautions to insure the safety of their patients, their co-workers and themselves and to insure effectiveness of the therapy or treatment. These safety precautions are also outlined in Reference No. 2.

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GROUP INHALATION THERAPY SESSIONS AND DEMONSTRATIONS

Bataan Memorial Hospital

Bernalillo County Medical Center

Presbyterian Medical Center

St. Joseph's Hospital

Veteran's Hospital

New Mexico Pediatric Pulmonary Center

Home Visits

# INHALATION THERAPY EQUIPMENT AND TECHNIQUES - BATAAN MEMORIAL HOSPITAL

George A. Cowman, R. I. T.
Johathan Paden, I. T. T.

Departmental Organization and Administration

- Ideal Organization
- Role of Inhalation Therapy in Total Patient Care
- Role of Inhalation Therapy Organizations
- Training - Inhalation Therapy Staff, Nursing, and Medical Staff

Equipment Needed to Provide All-Around Therapy

- Pressure Breathing Units
- Aerosol Therapy Units.
- Varied Techniques

How Inhalation Therapy Should Be Ordered

- Routine Orders
- Combinations of Different Types of Therapy

Sterilization and Maintenance of Apparatus

- Cleaning Techniques
- Sterilization Techniques
- Special Procedures

Demonstrations and Tours

- Bataan Pediatric Unit
- Bataan Inhalation Therapy Department
- Equipment Demonstrations During Presentations
- Technique Demonstrations During Presentations

A WELL-EQUIPPED INHALATION THERAPY DEPARTMENT FOR PEDIATRICS SHOULD HAVE:

I.P.P.S. UNITS, BOTH AUTOMATIC PATIENT CYCLED AND MANUAL

ULTRASONIC AEROSOL GENERATOR - FOR BOTH

- CONTINUOUS THERAPY
- INTERMITTENT THERAPY

CONVENTIONAL AEROSOL GENERATORS

OXYGEN ANALYZER

HYGROMETER - WET BULB TYPE

EFFICIENT RESUSCITATION APPARATUS

- BAG TYPE
- OXYGEN POWERED RESUSCITATOR/INHALATOR

TRACHIAL AND OTO-PHARYNGEAL ASPIRATORS

CONTROLLED ENVIRONMENT UNITS -

- ISOLETTE TYPE UNITS
- OXYGEN/AEROSOL TENTS

MONITORING CAPABILITIES

- RESPIRATION
- OXYGEN CONCENTRATION
- CARDIAC

MEMORANDUM

TO: Mr. H. M. Kelly, Executive Vice President
Dr. John Birch, M. D., Medical Director, Department of Inhalation Therapy

FROM: Mr. George Cowman, Supervisor, Department of Inhalation Therapy

SUBJECT: Statistical Report for the Month of January, 1971

| | | |
|---|---|---|
| **Scheduled Therapy:** | | |
| IPPB Treatments Given (In Patients) | | 3220 |
| IPPB Treatments Given (Out Patients) | | 16 |
| Total IPPB Treatments Given | | 3236 |
| Ultrasonic Nebulizer Treatments | | 531 |
| **Continuous Ventilation Cases:** | | |
| IPPV Therapy | 14 Patients | 65 Patient Days |
| **Oxygen Administration:** | | |
| Oxygen Mask | 11 Patients | 63 Patient Days |
| Oxygen Cannula | 41 Patients | 658 Patient Days |
| Oxygen Catheter | 1 Patient | 2 Patient Days |
| Oxygen Tent | 2 Patients | 4 Patient Days |
| **Aerosol Therapy:** | | |
| Croupettes and Isolettes | 12 Patients | 100 Patient Days |
| Room Humidifier | 9 Patients | 63 Patient Days |
| Continuous USN | 0 Patients | 0 Patient Days |

It is interesting to note that during January 1970 we administered:

1473 IPPB Treatments
113 Ultrasonic Nebulizer Treatments

This amounts to approximately a 220 per cent increase in IPPB's for this period; and approximately a 470 per cent increase in Ultrasonic Aerosol Therapy for this period, also.

Submitted by,

(s) George Cowman

# OUTPATIENT INHALATION THERAPY

Mary Ann Zurek, R. N.

I. Office Procedures and Equipment

- A. Intermittent Positive Pressure Breathing Therapy
  - 1. Purpose
  - 2. Units
  - 3. Procedure of Treatment
  - 4. Maintenance
- B. Ultrasonic Therapy
  - 1. Sputum Collection Procedure
  - 2. Treatment Procedure
  - 3. Maintenance of Equipment

II Home Procedures and Equipment

- A. Purpose
- B. Types of Therapy
  - 1. Simple Aerosol Therapy
  - 2. Ultrasonic Therapy
  - 3. Mist Tent Therapy
  - 4. Vaporizer
- C. Maintenance of Equipment

References:

Levine, Edwin R., "Effective Inhalation Therapy", Chapter 25, Page 136, Chapter 28, Page 145, and Chapter 29, Page 150.

Goddard, R. F., and U. C. Luft, "Intermittent Positive Pressure - Aerosol Therapy in Pediatrics", Dis. Chest 24:616, June, 1956.

Goddard, R. F., and T. T. Mercer, et al, "Output Characteristics and Clinical Efficacy of Ultrasonic Nebulizers", J. Asthma Res., V. 355:368, June, 1968, Revised, February, 1969.

# HOME INHALATION THERAPY

L. Milburn, M. D.
P. Sithiku, M. D.

Standard Home Therapy Cystic Fibrosis Unit

Mist-$O_2$-Gen HH-16-5 Canopy (0443)

1 MC-107 Mist-$O_2$-Gen Compressor

2 MG-11C Mist-$O_2$-Gen Mechanical Nebulizers

1 0606 Bennett Plastic Face Piece

1 0609 Bennett Face Cushion

1 0647 Bennett Mask Valve

1 2814 Bennett Twin Jet Nebulizer

1 52" plastic tubing (T-tube and nipple)

Ultrasonic Nebulizer - DeVilbiss, Model 3584

Postural Drainage Board or Arrangement

Cold Mist Vaporizer

VISITS AND DEMONSTRATIONS - OTHER HOSPITAL INHALATION THERAPY DEPARTMENTS

BERNALILLO COUNTY MEDICAL CENTER

PRESBYTERIAN MEDICAL CENTER

ST. JOSEPH HOSPITAL

VETERAN'S HOSPITAL

SECTION VI APPENDICES

A. THE NEW MEXICO PEDIATRIC PULMONARY CENTER

B. HOSPITAL AIDS

C. POSTURAL DRAINAGE INSTRUCTIONS

D. AIRWAY OBSTRUCTIONS

E. INHALATION THERAPY

F. PULMONARY FUNCTION AIDS

APPENDIX A

NEW MEXICO PEDIATRIC PULMONARY CENTER

PEDIATRIC PULMONARY CENTER
OF THE NEW MEXICO REGIONAL MEDICAL PROGRAM

5200 Gibson Boulevard, Southeast • Albuquerque, New Mexico 87108 • Telephone (505) 265-1211

September 1, 1970

## WHAT IS THE PEDIATRIC PULMONARY CENTER?

The Pediatric Pulmonary Center is one of six such centers in the United States aluthorized by the 90th Congress as an integral part of the chronic disease division of the Public Health Service. The establishment of such a program is one of the first recognitions of the importance of chronic pulmonary diseases in all ages in the U. S. population. The New Mexico Pediatric Pulmonary Center is one of eight projects of the New Mexico Regional Medical Program and has been approved for a three year period starting July 1, 1968. The Pediatric Pulmonary Center opened its doors to the first clinical patients on November 1, 1968.

## OBJECTIVES

The objectives of the Pediatric Pulmonary Center are to offer a diagnostic and evaluation service for chronic, non-tuberculous pulmonary disease in children to the physicians of New Mexico and the surrounding areas. In addition to offering services to patients, one of the major functions will be to train and educate physicians, medical students, nurses, paramedical personnel, and technicians in the diagnostic evaluation of children with chronic, non-tuberculous respiratory diseases, and in the use of the most recent advances in therapeutic techniques in their treatment.

## PATIENT ELIGIBILITY AND REFERRAL

Any child in New Mexico or adjacent areas is eligible for referral to the Center. He may be referred by a physician, the Department of Public Health, or other medical or social referral agency. Patient costs for cases selected for demonstration by the Center will be provided by the program. All other patient fees will be provided by either the patient himself or health insurance programs, medicaid, or by agencies which assist in the care of crippling diseases and rehabilitation programs for children. Once the patient has been diagnosed and evaluated, he will be sent back to his referring physician or may be asked to return for a follow-up visit, dependent on the educational and program demonstration needs.

## ORGANIZATION AND OPERATION OF THE CENTER

The Center is located in the Bataan Rehabilitation Center and has hours from 8:00 A. M. to 5:00 P. M. on Tuesday and Friday of each week. The staff of the Center includes a medical director, assistant director, clinical trainee, social worker, physical therapist, inhalation therapist, pediatric nurse, pulmonary physiologist and related paramedical personnel. The Department of Pediatrics of the University of New Mexico School of Medicine will offer consultation services and actively engage in teaching programs of the Center. Other consultants may be called upon from practicing pediatricians and other specialists throughout the state.

EDUCATIONAL PROGRAMS

The major portion of the demonstration and educational program will be conducted in the Center itself. This will include patient work-ups by externs, residents and fellows; patient conferences; and lectures and demonstrations related to chronic pulmonary diseases in children. Teaching teams will travel throughout the state, giving demonstrations and lectures in the smaller communities, and additional televised educational programs will be telecast throughout New Mexico. In addition, special courses will be conducted in the Center in pediatric pulmonary physiology and inhalation therapy for infants and children. Each of these will be one week in duration and open to physicians, nurses, lab technicians, physiotherapists, inhalation therapists and any other paramedical personnel interested in the diagnosis of pulmonary diseases in children. These courses will include lectures on the clinical, pathological and physiological relationships of respiratory diseases in children; demonstrations of pulmonary function testing and inhalation therapy; and practical experience in the Center, in the laboratory and on the hospital ward.

RESEARCH PROGRAMS

Research now being conducted by the Pediatric Research Department of the Lovelace Foundation for Medical Education and Research will continue in the areas of pulmonary physiology; improved diagnostic methods in the evaluation of chronic, non-tuberculous diseases in children; investigation of emotional and intellectual factors in children with chronic respiratory diseases; aerosol studies; developmental studies in inhalation therapy equipment for infants and children; and a collaborative study with Dr. John Leppi, of the University of New Mexico Medical School, in the area of mucosaccharides of epithelial and connective tissue.

Inquiries concerning referral of patients, the operation of the Center, and any of its programs, should be addressed to the medical director of the Pediatric Pulmonary Center of the New Mexico Regional Medical Program, 5200 Gibson Blvd., S. E., Albuquerque, New Mexico, 87108.

Roy F. Goddard, M. D.
Medical and Project Director

RFG:aa

PEDIATRIC PULMONARY CENTER OF THE NEW MEXICO REGIONAL MEDICAL PROGRAM

PATIENT REFERRAL FORM

Name of Patient:_____Age:_____Sex:_____

School Attending:_____

Guardian or Parent:_____Phone:_____

Address:_____

MEDICAL HISTORY PERTINENT TO REFERRAL*

What is working diagnosis?_____

At what age was diagnosis established?_____

What criteria established the diagnosis?_____

1._____

2._____

3._____

When did you first see patient?_____

Major symptoms first noted and age:_____

Major symptoms now present:_____

Major problems in handling the patient:_____

What is present treatment and management program?

Diet:_____

Vitamins, etc.:_____

Medications:_____

Respiratory aids:_____

What is activity level of patient?_____

*Include any other pertinent information on back or on additional page.

Referring Physician:_____

Address:_____Phone:_____Date:_____

PEDIATRIC PULMONARY CENTER
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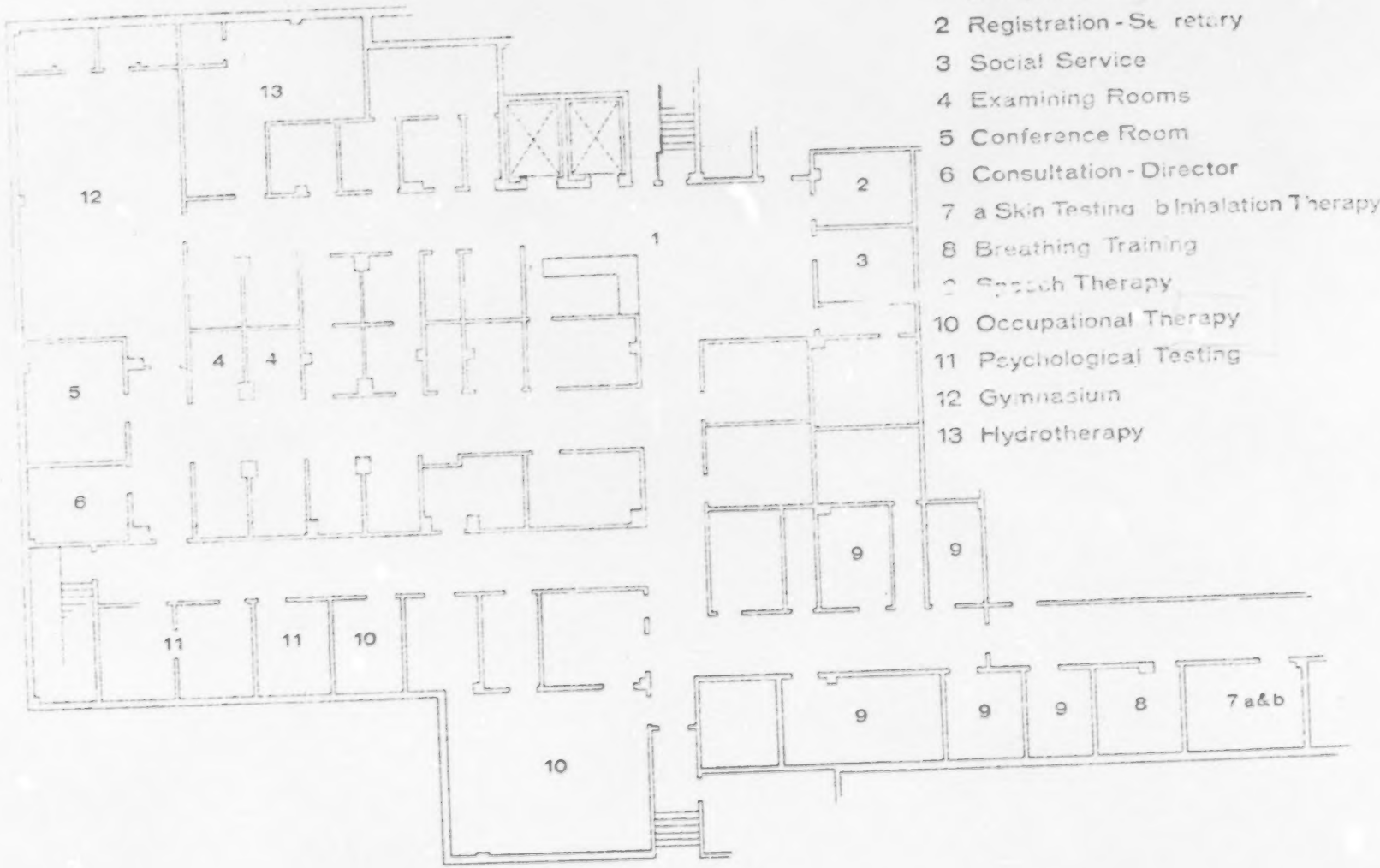
# THE PROGRESS OF A PATIENT THROUGH THE PEDIATRIC PULMONARY CENTER

1. Inquiry
2. Information Relevant to Referral
3. Referral Letter and Form
4. Registration
5. Social Service Intake
6. Medical Work-Up
   a. History
   b. Physical Exam
   c. Discussion and Demonstration
   d. Outline of Evaluation
7. Laboratory Evaluation
   a. Original Visit - Center
   b. Laboratory Studies
   c. X-ray
   d. Pulmonary Function
   e. Allergic Skin Tests
   f. Additional Evaluations (including Photographs, Eye Examination, etc.)
8. Follow-Up Visit
   a. Results of Studies
   b. Summary
   c. Outline of Therapy
9. Consultations
   a. Physical Therapy
   b. Inhalation Therapy
   c. Psychological Guidance
   d. Vocational Guidance
   e. Dietary Advice
   f. Other
10. Report and Return to Referring M. D., Agency, etc.
11. Subsequent Follow-Up at Pediatric Pulmonary Center
    a. Quarterly, Semi-Annually, Annually
    b. Education and Demonstration
12. Community Visitation

# PEDIATRIC PULMONARY CENTER




1 Reception Area
2 Registration - Secretary
3 Social Service
4 Examining Rooms
5 Conference Room
6 Consultation - Director
7 a Skin Testing b Inhalation Therapy
8 Breathing Training
9 Speech Therapy
10 Occupational Therapy
11 Psychological Testing
12 Gymnasium
13 Hydrotherapy

PEDIATRIC PULMONARY CENTER OF THE NEW MEXICO REGIONAL MEDICAL PROGRAM

SOCIAL SERVICE FACE SHEET

Patient Name _____

Age _____ Date of Birth _____ Place _____

Sex _____ M S D S Race _____ Religion _____

Lovelace Clinic No. _____ C. F. No. _____ Initial date _____

Diagnosis at Referral _____ Date of Diagnosis _____

Physician Who Made Diagnosis _____

Referral Source _____

Report _____

School _____

Occupation or Major _____

No. of Days Missed Per Year _____ No. of Hospitalizations _____

Address _____ Phone _____

Father _____ Medical _____

Mother _____ Medical _____

Father Date of Birth _____ Place _____

Mother Date of Birth _____ Place _____

M S D S Mother Address _____

M S D S Father Address _____

Length of Residence in New Mexico _____

Pediatric or Family Physician _____

Name of Interviewer _____ Date _____

Additional Comments: _____

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TO WHOM IT MAY CONCERN

I have this day examined _____,
who has _____. It would be appreciated if you would allow him to participate to his fullest capacity in physical education activities. If he starts to wheeze or cough, he should be excused from physical education for the remainder of that day. Vigorous exertion and running activities may also be a reason for excusing him from the activities of that day. On dusty, windy days he should be allowed to remain indoors.

Thank you for consideration of this student. It is our hope that he will be able to participate in your physical education programs, and that we can work together for his best interests in developing his physical fitness and health to optimum potential. If you have any questions concerning this student, please feel free to contact me.

Sincerely,

PEDIATRIC PULMONARY CENTER

# APPENDIX B

## HOSPITAL AIDS

## ANTIBIOTIC DOSAGES FOR CHILDREN

| Drug | Dose/Day | Max/Day | Route |
|---|---|---|---|
| Penicillin | 600,000 - 1,200,000 units | No limit | IM |
| Penicillin | 800,000 - 1,600,000 units | No limit | Oral |
| Dimethoxypenicillin | 100 mg/kg | No limit | IM |
| Sodium Oxacillin | 100 - 300 mg/kg | No limit | Oral |
| Sodium Cloxacillin | 50 - 100 mg/kg | | Oral |
| Sodium Dicloxacillin | 15 - 25 mg/kg | | Oral |
| Ampicillin | 50 - 200 mg/kg | | Oral |
| Carbenecillin | 100 - 400 mg/kg | | IV |
| Erythromycin | 20 - 50 mg/kg | 2 gms | Oral |
| Tetracycline | 30 - 100 mg/kg | 3 gms | Oral |
| Sulfonamides | 0.2 gms/kg | 4 gms | Oral |
| Cephalothin | 40 - 120 mg/kg | 4 gms | IM |
| Chloramphenicol | 50 - 100 mg/kg | 3 gms | Oral |
| Gentamycin | 2 - 4 mg/kg | 80 mg | IM |
| Colymycin | 3 - 7 mg/kg | 300 mg | IM |
| Polymyxin B | 2.5 mg/kg | 150 mg | IM |
| Kanamycin | 15 - 30 mg/kg | 2 mgs | IM |
| Novobiocin | 30 - 50 mg/kg | 2 mgs | IM |
| Bacitracin | 1,000 units/kg | 75,000 | IM |
| Neomycin | 7.5 - 15 mg/kg | | IM |
| Isoniazide | 10 - 20 mg/kg | 500 mg | Oral |
| PAS | 200 mg/kg | 12 gm | Oral |
| Streptomycin | 50 - 75 mg/kg | 2 gms | IM |

## AEROSOL ANTIBIOTIC THERAPY

| Antibiotic | Concentration | Volume Administered |
|---|---|---|
| Penicillin | 100,000 Units/ml. | 2 ml. |
| Dimethoxypenicillin | 100-250 mg./ml. | 2 ml. |
| Neomycin | 50-100 mg./ml. | 2 ml. |
| Kanamycin | 50 mg./ml. | 2 ml. |
| Polymyxin | 4 mg./ml. | 2 ml. |
| Chloromycetin succinate | 50-100 mg./ml. | 2 ml. |
| Bacitracin | 5,000 Units/ml. | 2 ml. |
| Streptomycin | 50 mg./ml. | 2 ml. |

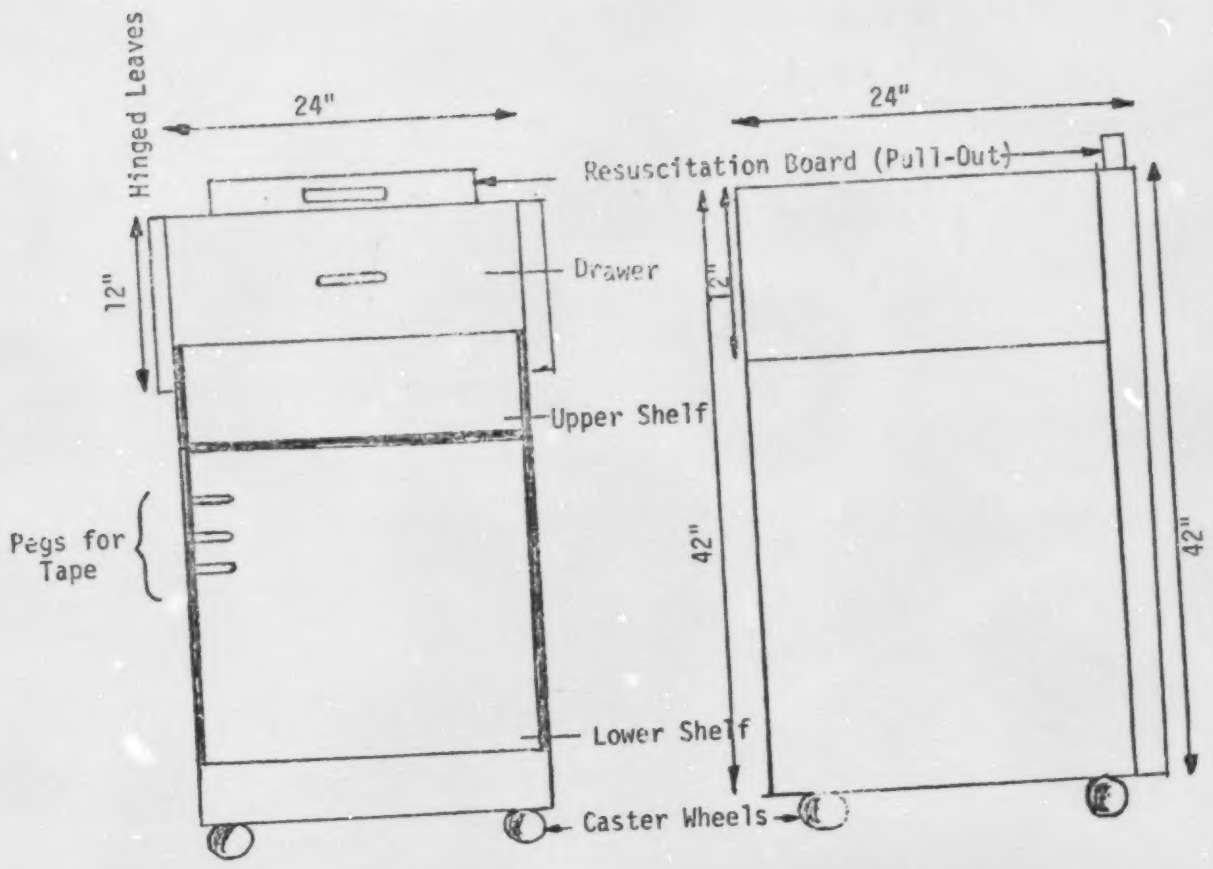
## CONSTITUENTS OF AEROSOL SOLUTIONS

℞
Propylene Glycol USP, 10 ml.
0.125% Neosynephrine HCl, q.s. to 100 ml.
Sig. Give 2 ml. by aerosol, t.i.d. or q.i.d.

℞
Neomycin Sulphate, 10 gms.
Propylene Glycol USP, 20 ml.
0.125% Neosynephrine HCl, q.s. to 200 ml.
Sig. Give 2 ml. by aerosol, t.i.d. or q.i.d.

℞
Solution 1
Propylene Glycol USP, 10 ml.
0.125% Neosynephrine HCl, q.s. to 100 ml.
Solution 2
Isuprel solution 1:200, 10 ml. bottle
Sig. Mix 1.6 ml. of Solution 1 with 0.4 ml. of Solution 2 and give by aerosol, t.i.d. or q.i.d.

PEDIATRIC EMERGENCY CART




Equipment for Cart on following pages.

Would suggest an electrical outled on cart.

Pediatric Emergency Cart - Each square = 3"

## PLAN FOR A PEDIATRIC EMERGENCY CART

LOWER SHELF:

250 cc 5% dextrose/normal saline
250 cc 5% dextrose/Ringer's Lactate
250 cc 5% dextrose/water
250 cc 0.45% Na Cl/5% dextrose
250 cc 0.33% Na Cl/5% dextrose
250 cc 0.2% Na Cl/5% dextrose
250 cc Ringer's Lactate
Alcohol sponges
Adhesive and/or paper tape
G. B. L. manual resuscitator
Nasogastric tube
Flashlight

UPPER SHELF:

Laryngoscope tray
Cut-down tray
Pediatric tracheotomy tray
Replacement requisitions

DRAWER:

Syringes:
- 50 cc syringe
- 20 cc syringe
- 5 cc syringes (2)
- Tuberculin syringes (2)
- Needles

Intravenous Equipment:
- Microdrip set
- Blood administration set
- Vacutainer and tubes
- Scalp vein needles (#23, #21, #25)

Additional Equipment:
- Scalpel with blades
- Padded tongue blades
- Cardiac needles (#19, #18, #22)
- Files
- Tourniquet

## EMERGENCY CART DRUGS

IN EMERGENCY CART DRAWER:

Sodium bicarbonate 50 cc ampules (2)
5% Dextrose/water 50 cc ampule
Epinephrine chloride 1:1000
Ephedrine
Isoproterenol (Isuprel) 1:200
Diphenhydramine hydrochloride (Benadryl)
Laverterenol (Levophed)
Aminophylline 250 mgm (2)
Caffeine sodium benzoate
Calcium chloride (1)
Cedilanid
Diazepam (Valium)
Nalorphine (Nalline)
Chlorpromazine
Phenobarbital
Prostigmine
Dilantin
Potassium chloride

IN EMERGENCY BOX:

Nikethamide (Coramine)
Quinidine gluconate
Digoxin
Sodium Amytal
Solu-Cortef
Glucagon
Sodium lactate

## NURSING CARE PLAN

Goal

| Date | PROBLEMS and NEEDS | APPROACH |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

Age Birthdate Religion Siblings-Status Adm. Date

Room Name Diagnosis Doctor

APPENDIX C

POSTURAL DRAINAGE INSTRUCTIONS

# POSTURAL DRAINAGE INSTRUCTIONS*

FOR PATIENTS

OF THE

PEDIATRIC PULMONARY CENTER

OF

NEW MEXICO REGIONAL MEDICAL PROGRAM

These instructions are designed to assist in the technique of postural drainage by showing each position of drainage. The area to be drained in each position is shown by the darkened portion of the bronchial tree. Instruction is given by the physical therapist in the technique of vibration and clapping.

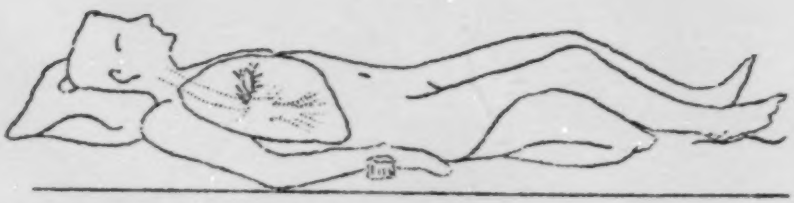
Alvin Becker, Physical Therapist

*Courtesy of Sandra Madden and
Department of Physical Medicine
University of Minnesota
Minneapolis, Minnesota

Position 1. Right Upper lobe - Apical Bronchus

The patient sits upright and leans slightly backward, then forward, and then sideward according to the area to be drained.

Position 2. Right and Left Upper Lobes - Anterior Bronchi



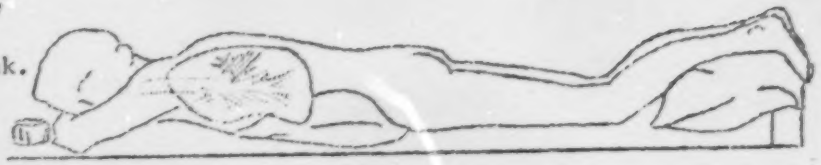
The patient lies on his back.

Position 3. Right Upper Lobe - Posterior Bronchus

The patient lies on his left side with the right side of the body turned forward to an angle of 45°. A pillow is placed in the left armpit and under the left chest for support.

Position 4. Right and Left Lower Lobes - Superior Bronchi

The patient lies facing downward with a pillow under the abdomen in order to flex the trunk.



Position 5. Left Upper Lobe - Apical - Posterior Bronchus

The patient lies on the right side with the left side of the body turned forward to an angle of about 45°. A pillow is placed in the right armpit and under the right chest for support.

Position 6. Left Upper Lobe: Lower Division - Superior and Inferior Bronchi

The patient lies on his back and right side with the body turned to an angle of about 45°. The back is supported with a pillow from under the left shoulder to the left hip. The food end of the bed or table is elevated about 12 inches.

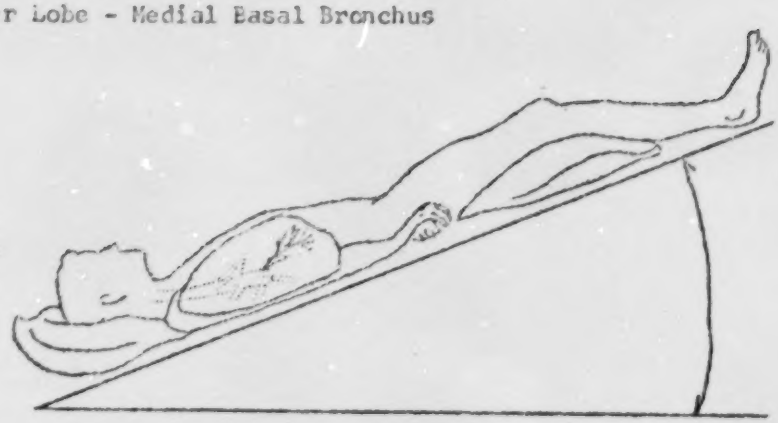
Position 7. Right Middle Lobe - Lateral and Medial Bronchi

The patient lies on his back and left side with his body turned to an angle of about 45°. The back is supported with a pillow from under the right shoulder to the right hip. The foot end of the bed or table is elevated about 12 inches.

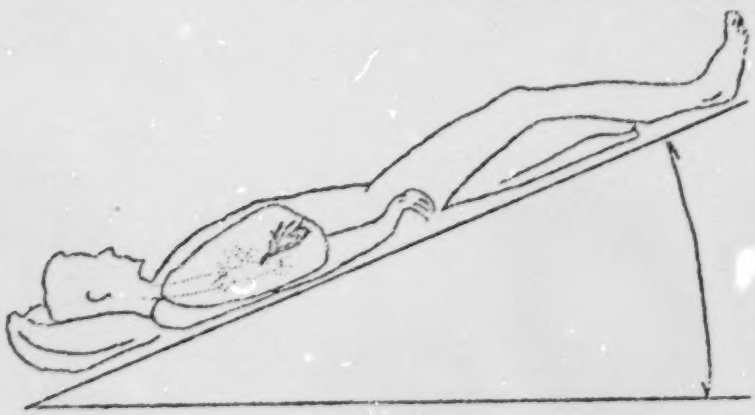
C4

Position 8. Right Lower Lobe - Medial Basal Bronchus

The patient lies on his back and the foot end of the bed or table is elevated 18 inches.



Position 9. Right Lower Lobe - Anterior Basal Bronchus



The patient lies on his back with the body turned slightly onto the left side. The foot end of the bed or table is elevated 18 inches.

Position 10. Right Lower Lobe - Lateral Basal Bronchus

The patient lies on the left side and a pillow is placed under the left lower ribs and hip bones. The foot end of the bed or table is elevated 18 inches.

Position 11. Left Lower Lobe - Lateral Basal Bronchus

The patient lies on the right side and a pillow is placed under the right lower ribs and hip bones. The foot end of the bed or table is elevated 18 inches.

Position 12. Left Lower Lobe - Anterior Medial Basal Bronchus

The patient lies on his back with the body turned slightly onto the right side. The foot end of the bed or table is elevated 18 inches.

Additional Instructions

APPENDIX D

CLASSIFICATION OF AIRWAY OBSTRUCTION

CONSEQUENCES OF AIRWAY OBSTRUCTION

PATHOPHYSIOLOGY OF AIRWAY OBSTRUCTION

MANAGEMENT OF AIRWAY OBSTRUCTION

SUMMARY OF EMPHYSEMA IN CHILDHOOD

RESPIRATORY INSUFFICIENCY

ACID-BASE BALANCE

AIRWAY OBSTRUCTION

1. Etiological Factors

   Congenital Anomaly

   Disease - Infection

   Mechanical

   Neuro-muscular

2. Site

   Respiratory Tract

      Upper

      Mid-

      Lower

   Thorax

   Abdomen

   CNS

3. Physiologic Types

   Simple Obstruction

   Cystic Obstruction

   Insufficient Pressure Gradient

   Decreased Distensibility of Lung and Thorax

## CONSEQUENCES OF AIRWAY OBSTRUCTION

1. Simple Obstruction

| Type | Consequence | Clinical Example |
|---|---|---|
| ↓ Airway Circumference | ↑ Airway Resistance (I, E, >E) | Bronchospasm |
| Luminal Obstruction | ↑ Airway Resistance (E, I, >E) (Turbulent Flow Likely) | Tumor, Foreign Body, Blood Secretions |
| ↑ Length of Airways | ↑ Airway Resistance (I, E, >E) | Elongation of Smallest Airways (Emphysema) |

## CONSEQUENCES OF AIRWAY OBSTRUCTION

### 2. Cyclic Obstruction

| Type | Consequence | Clinical Example |
|---|---|---|
| Ball-Valve Phenomenon | ↑ Airway Resistance (I or E Depending on Shape and Location of B-V) | Secretions and Blood in Smaller Airways<br>Tumor in Major Airways |
| Wall Weakness | ↑ Resistance - E | Emphysema |

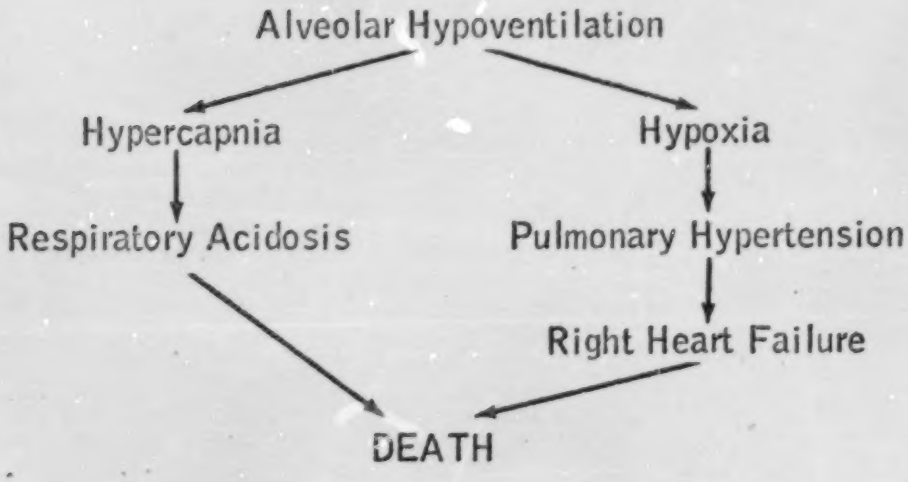
### 3. Insuffficient Pressure Gradient

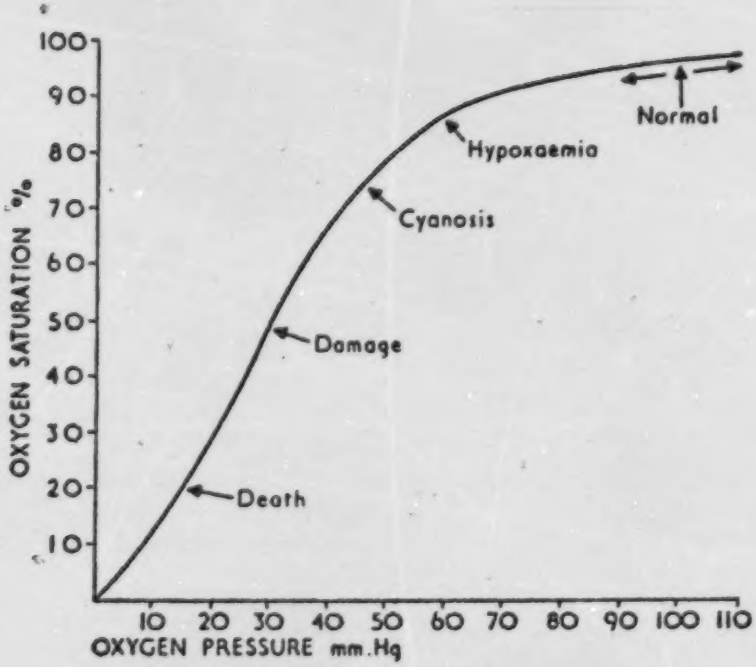
| Type | Consequence | Clinical Example |
|---|---|---|
| ↓ Respiratory Muscles Activity | ↓ Inspiratory Effort | CNS Muscular Weakness |
| ↓ Elastic Lung Recoil | ↓ Expiratory Effort | Emphysema |

### 4. Decreased Distensibility of Lung and Thorax

| Type | Consequence | Clinical Example |
|---|---|---|
| Uniformly Across Lungs | ↓ Distensibility | Pulmonary Fibrosis<br>Obesity<br>Kyphoscoliosis<br>Pulmonary Congestion |
| Localized to Part of Lung | Uneven Ventilatory Distribution | Emphysema<br>Atelectasis-Pneumonia<br>Abdominal Distention |

# PATHOPHYSIOLOGY OF AIRWAY OBSTRUCTION




Oxygen dissociation curve.

D 5

MANAGEMENT OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Respiratory Failure

CorPulmonale and Pulmonary Hypertension

Infection

Complications

Surgery

RESPIRATORY FAILURE

Airway Obstruction

Infection

Hypoxemia

Hypercapnia and Respiratory Acidosis

Right Ventricular Failure

Dehydration

Metabolic Alkalosis and Acidosis

AIRWAY OBSTRUCTION

Inhalation Therapy

Bronchial Lavage

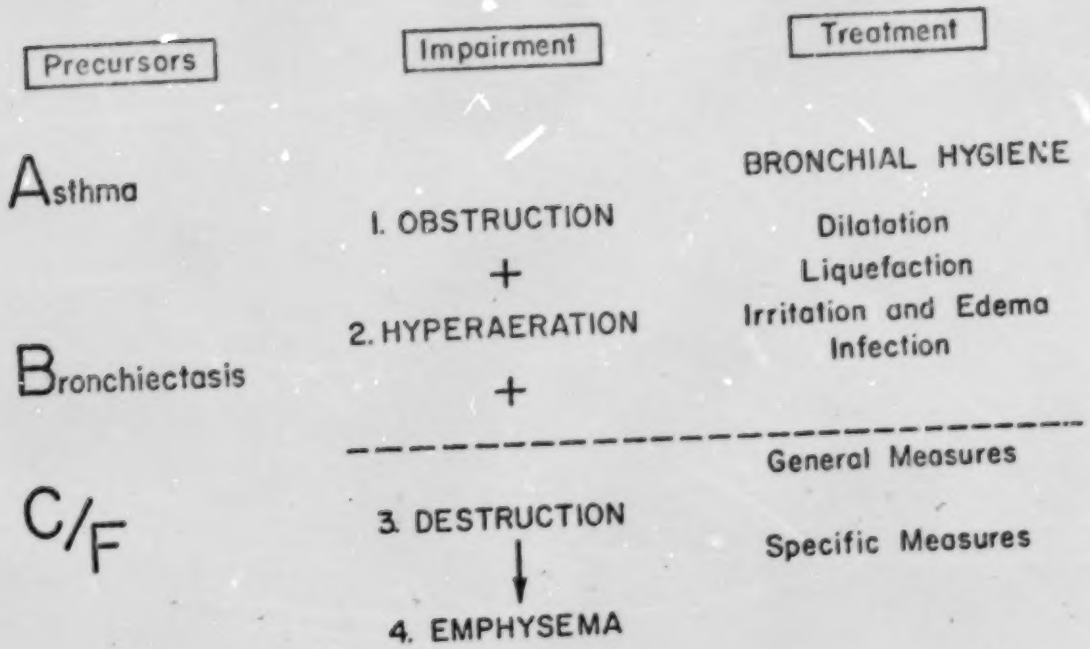
Bronchial Hygiene

Ventilation

Physical Therapy Measures

Supportive and Surgical Therapy

# SUMMARY OF EMPHYSEMA IN CHILDHOOD




References:

Goddard, R. F., "Pre-Emphysema in Children, Its Recognition and Treatment," Ann. Allergy 19:1125, 1961.

Goddard, R. F., "The Physiologic-Pathologic-Clinical Relationships of Chronic Pulmonary Diseases in Children, J. of Children's Asthma Research Institute and Hospital 1:31, 1961.

PULMONARY INSUFFICIENCY

A. PRECIPITATING FACTORS

1. Infection
2. Allergic (Ingestants and Inhalants)
3. Irritants
4. Triggers (Environment, Coughing, Otitis)
5. Emotional (Stress and Fatigue)

B. CLINICAL SIGNS

1. Anxious (Comatose, Flushed, Obstreperous, Tremors)
2. Cyanosis
3. Tachycardia (Diaphoresis, Increased Blood Pressure, Venous Distention)
4. Thorax (Increased AP Diameter, Increased Intercostal Spaces, Decreased Excursion, Retractions)
5. Breath Sounds, Wheezing
6. Abdominal Prominence

C. DIAGNOSIS AND MONITORING

1. Cultures
2. Blood gas, electrolytes
3. CBC, Urinalysis
4. Chest X-ray
5. Vital Signs
6. Pulmonary Function

PULMONARY INSUFFICIENCY (CONTINUED)

D. THERAPY OF ASTHMA

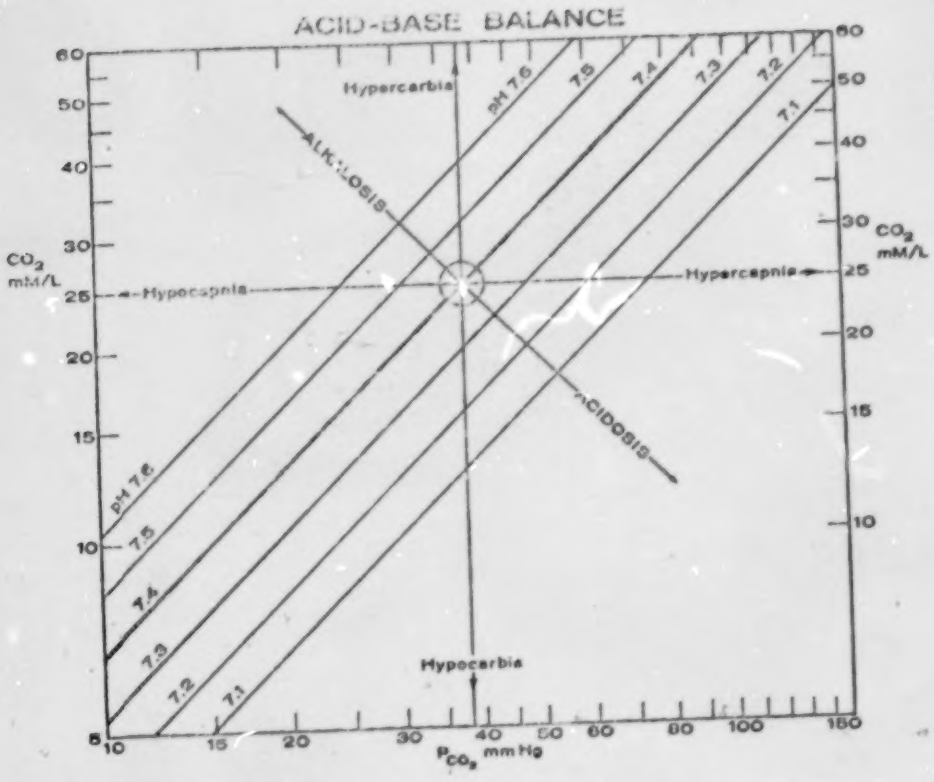
1. Removal from Precipitating Factors
2. Patent Airway
3. Fluids (IV, Oral)
4. Mist (Humidification, Liquefaction of Secretions, Water Loss)
5. Bronchodilators
6. Expectorants
7. Steroids
8. Bronchial Hygiene (Lavage)

E. THERAPY OF BLOOD GAS AND ACID-BASE ABNORMALITIES

1. Correction of Hypoxemiz ($O_2$)
2. Alkalinization ($NaHCO_3$, THAM)
3. Ventilation
4. Intubation, Tracheostomy

F. THERAPY OF COMPLICATIONS AND OTHER FACTORS

1. Infection
2. Cor Pulmonale
3. Sedation (Tranquilizers, Psychotherapy)
4. Pneumothorax (Pneumomediastinum, Subcutaneous Emphysema)
5. Respiratory Alkalosis (Adult)
6. Supportive Therapy (Breathing Exercises, Postural Drainage)
7. Reassurance, Hypnosis?
8. Surgical?
9. Prophylaxis
10. General: (Symptomatic, Medications, Nutrition, Infection)




## BASAL METABOLISM AND WATER REQUIREMENT PER 24 HOURS PER UNIT OF WEIGHT

| Weight | Metabolic Rate cal./kg. | Water ml./kg. | Water ml./lb. |
|---|---|---|---|
| * (age 2 days to 3 weeks) | 45-50 | 70 | 30 |
| 3-10 kg. | 60-80 | 100 | 45 |
| 10-15 kg. | 50-65 | 80 | 40 |
| 15-25 kg. | 40-50 | 70 | 30 |
| 25-35 kg. | 35-40 | 55 | 25 |
| 35-60 kg. | 30-35 | 50 | 25 |
| >60 kg. | 25-30 | 45 | 20 |

(Modified from Darrow, 1959)

*Newborn infants need no fluid for the first 48 hours of life.

## PRINCIPLES OF CARE FOR STATUS ASTHMATICUS*

| PRINCIPLES OF CARE | MEDICAL CONSIDERATIONS | NURSING CARE |
|---|---|---|
| Fatigue, dyspnea, severe distress, extreme anxiety are the most obvious symptoms of status asthmaticus. | 1. REST<br>Hospitalization: removes patient from contributing environment; spares the exertion of patient in home care.<br><br>Sedation: Used judiciously. | Check room for any allergenic sources.<br><br>Elevate head of bed to comfortable position to promote comfort...aide respirations.<br><br>Sympathetic, but strongly reassuring and calm attitude.<br><br>If a sedative is ordered, be alert to possible side effects, symptoms of overdosage, and patient's ability to bring up secretions.<br><br>ABSOLUTE BED REST |
| Eating and drinking may add to severity of dyspnea.<br><br>Large amounts of fluids are lost in water vapor, sweat, and urine (as much as 2500 ml/day in acute cases.)<br><br>Iced or cold fluids may cause reflex bronchospasm.<br><br>Large quantities of food may increase dyspnea. | 2. FLUIDS AND NUTRITION<br>I. V. fluids with electrolyte replacement as indicated.<br><br>Usually N. P. O. except for sips of fluids as tolerated.<br><br>I. V. therapy. | The exertion of taking nourishment is detrimental in acute status asthmaticus.<br><br>Strict intake and output should be observed from the time of admission.<br><br>If oral fluids are ordered offer fluids at room temperature or warm fluids. Assist the patient.<br><br>Known food allergies should be avoided.<br><br>Fluids are most important. Non-satiating liquids permit greater amounts of fluid intake.<br><br>If food is to be given, serve small amounts frequently rather than large meals. Feed the patient. Avoid any unnecessary movement. |

*Field, Richard C., 1969.

PRINCIPLES OF CARE FOR STATUS ASTHMATICUS (continued)

| PRINCIPLES OF CARE | MEDICAL CONSIDERATIONS | NURSING CARE |
|---|---|---|
| Sputum is thick from allergic or infectious reactions.<br><br>Mucous plugs may form leading to distal atelectasis and pneumonitis. | 3. EXPECTORANTS<br>Medications such as mucolytic agents and expectorants.<br><br>Sputum specimen for culture (if possible).<br><br>Antibiotics: may be started before culture reports are returned.<br><br>Adequate hydration: I.V. fluids, electrolytes, etc.<br><br>Blood studies.<br><br>Chest X-ray. | Medications should be given promptly as ordered.<br><br>Obtain sputum specimen as soon as possible after admission if patient has a productive cough. However, do not further exhaust the patient by repeatedly trying for a sputum specimen.<br><br>Laboratory work and x-rays should be ordered and done as expeditiously as possible. Chest film will usually be portable. |
| Epinephrine may be ineffective in status asthmaticus (epinephrine fast). Severe asthma (status asthmaticus is diagnosed when a severe attack continues over a 40 hour period. | 4. SPECIFIC BRONCHODILATORS<br>Alkalinization of pH may render epinephrine useful again... Na bicarbonate or Na lactate may be ordered.<br><br>Aminophylline (if patient has not been over-medicated with this drug prior to admission). | If patient has a nebulizer even though it is of little value, it is best not to increase his anxiety by removing it.<br><br>Have emergency medications available.<br><br>Y-tubing with "piggy-backed"..<br><br>Aminophylline as ordered. |
| A high percentage of these patients have respiratory infections. | 5. CONTROL OF INFECTION<br>Sputum culture.<br><br>Antibiotics.<br><br>C. B. C. | If patient has a productive cough, obtain a specimen as soon as possible, remembering percautions above.<br><br>Accurate T. P. R.<br><br>Order laboratory work promptly. |

PRINCIPLES OF CARE FOR STATUS ASTHMATICUS (continued)

| PRINCIPLES OF CARE | MEDICAL CONSIDERATIONS | NURSING CARE |
|---|---|---|
| Knowledge of previous medication determines whether or not this patient will respond to these drugs. | 6. ACTH AND CORTICOSTEROIDS | Watch for side effects of drugs. Most side effects are due to prolonged intake and large doses of these drugs. Of primary concern in this is careful observation for changes in the patient's condition. That is, the physician will wnat to know if the drug is effective or of little value in this patient. |
| An allergen-free moist atmosphere with increased oxygen is beneficial to these patients.<br><br>Since oxygen is drying to the mucous membranes, humidity is required. High concentrations of oxygen may lead to hypercapnia, hypoventilation and depressed respirations.<br><br>Lethargy, confusion and coma may ensue. Narcosis from increasing carbon dioxide retention with progressive hypoventilation.<br><br>High oxygen concentration may lead to decrease in body nitrogen in paranasal sinuses and middle ear may cause vacuum-like pain. | 7. SUPPORTIVE THERAPY<br><br>I. C. U.: if available, a room with air filtration and humidity control is desirable.<br><br>Oxygen therapy: a tent will provide necessary humidity and temperature control if a room with these features is not available.<br><br>Observation for signs of increasing carbon dioxide concentrations.<br><br>Pulmonary studies.<br><br>Blood gas studies.<br><br>Nitrogen levels.<br><br>Remove from oxygen to atmospheric air if necessary. Valsalva maneuver on patients who can tolerate this. | Check oxygen concentration in tent.<br><br>Check humidity.<br><br>Observe for respiratory distress.<br><br>Assist with any studies, preventing any exertion on the patient's part if possible.<br><br>Close observation of any change in consciousness. Report any change to physician. This is one of the most crucial aspects of nursing care of these patients.<br><br>If patient complains of vacuum-type pain in ear notify doctor immediately. Do not remove the patient from oxygen without first consulting the physician. |

APPENDIX E

ORGANIZATION OF AN INHALATION THERAPY DEPARTMENT

SITES OF AFFLICTION OF RESPIRATORY CONDITIONS
IN THE YOUNGER AGE GROUPS

INFANT RESUSCITATION

NEBULIZATION THERAPY - GENERAL CONSIDERATIONS

POSTULATED SITES OF DEPOSITION OF PARTICLE SIZES
IN CHILD'S RESPIRATORY TRACT

SUMMARY OF INDICATED THERAPY

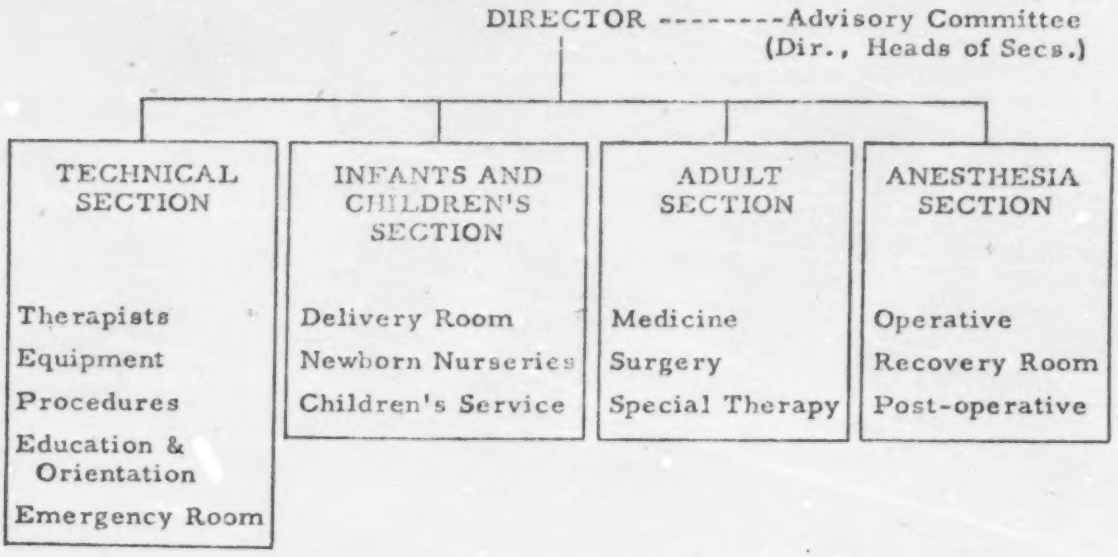
INHALATION THERAPY ORDER FORMS

OXYGEN THERAPY

INTERMITTENT POSITIVE PRESSURE BREATHING

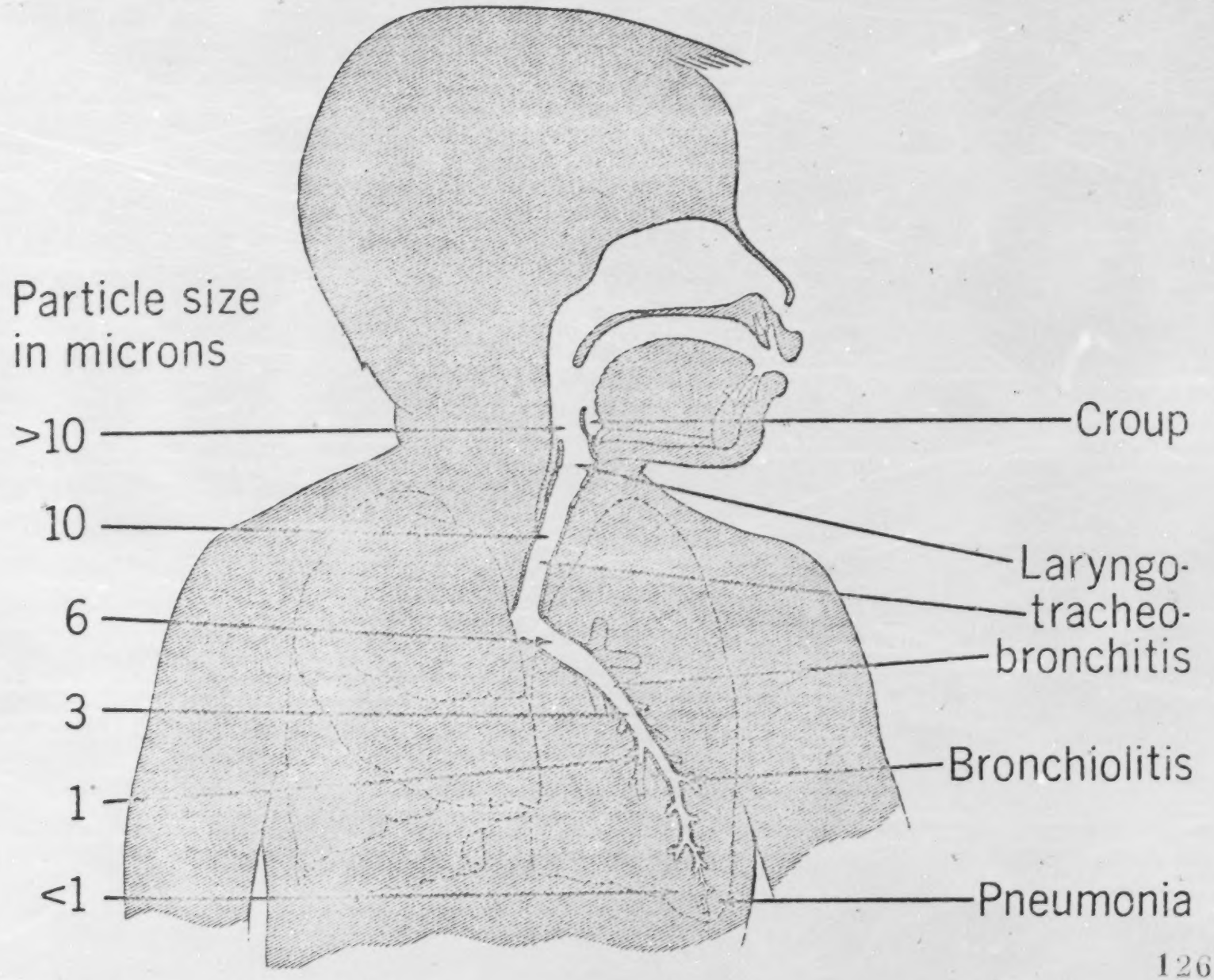
AEROSOL GENERATOR OUTPUTS AND DROPLET SIZES

## SUGGESTED INHALATION THERAPY ORGANIZATION FOR A GENERAL HOSPITAL




### *INHALATION THERAPY EQUIPMENT AND SERVICES FOR INFANTS AND CHILDREN*

| Equipment | Service |
|---|---|
| Resuscitator/Inhalator | Delivery Room<br>Nursery<br>Children's Service<br>Emergency Room<br>Office |
| Respirator | Nursery<br>Children's Service |
| Incubator | Nursery<br>Children's Service |
| Nebulizers and Humidifiers | Nursery<br>Children's Service<br>Office<br>Home |
| Oxygen | Nursery (with control)<br>Children's Service<br>Emergency Room<br>Delivery Room<br>Office<br>Home |
| Compressed Air or Gases (Cylinders, piped, or approved compressors) | Nursery<br>Children's Service<br>Office<br>Home |
| Croup Tents, Hoods, Tents, Masks, Face Tents | Children's Service<br>Home |
| IPPB Therapy Units | Children's Service<br>Emergency Room<br>Office<br>Home |
| Suction Apparatus | Delivery Room<br>Emergency Room<br>Nursery<br>Children's Service<br>Office |

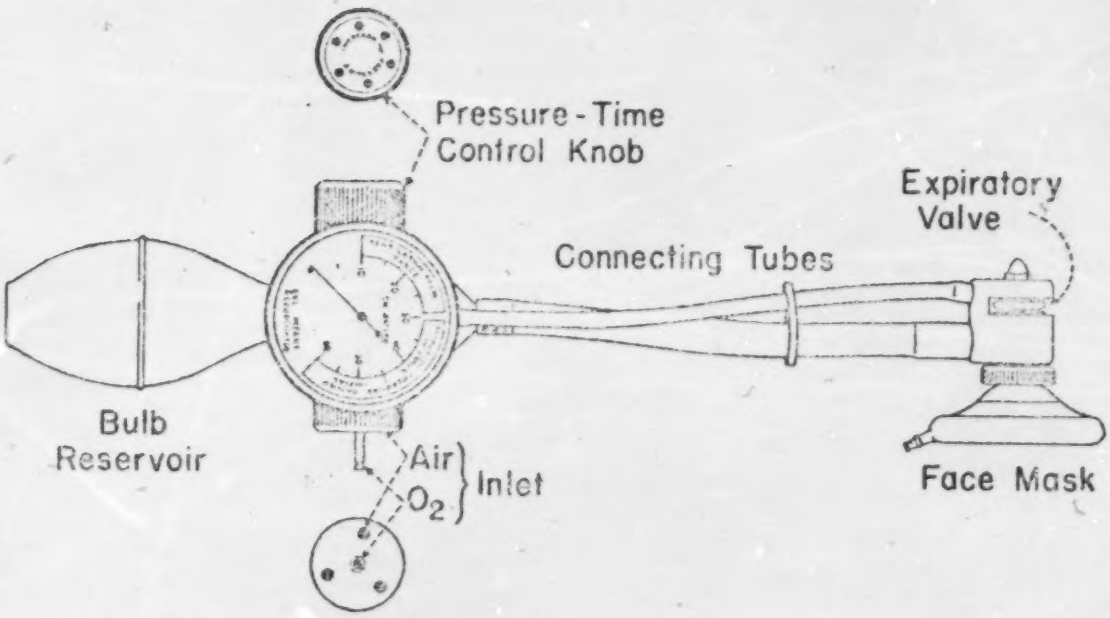

Particle size
in microns
>10
10
6
3
1
<1
Croup
Laryngo-
tracheo-
bronchitis
Bronchiolitis
Pneumonia

E3

125

126

MOUTH TO MOUTH RESUSCITATION




SKETCH OF GBL INFANT RESUSCITATOR

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## THERAPY AIMED AT THE BRONCHIAL OBSTRUCTION METHODS

OBJECTIVES:

1. To decrease the viscosity of the pulmonary secretions
2. To improve pulmonary hygiene

PHYSICAL METHODS--AIMED AT LIQUEFYING SECRETIONS

- Aerosol treatments
- Mist tents
- Home humidifiers

PHYSICAL METHODS--AIMED AT INCREASING DRAINAGE OF SECRETIONS

- Postural drainage
- Chest vibration and clapping
- Breathing exercises
- Physical activity
- Intermittent positive pressure breathing treatments (in special cases)

## NEBULIZATION THERAPY - GENERAL CONSIDERATIONS

OBJECTIVES

PARTICLE SIZE

NEBULIZER (TYPE AND ADEQUACY)

SOURCE OF NEBULIZATION

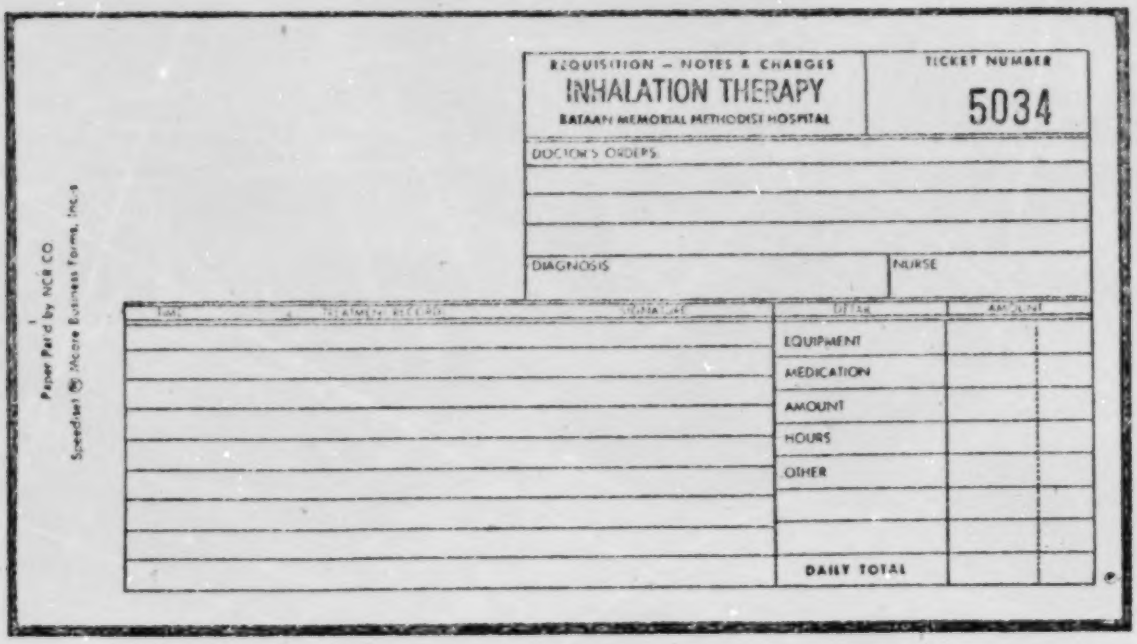
SOLUTIONS

CLEAN EQUIPMENT

Summary of Indicated Therapy in Bronchopulmonary Diseases of Infants and Children

| Example | Therapy Indicated |
|---|---|
| Premature Infant | Augmented respiration. |
| Hyaline Membrane Syndrome | Maintain clear airways.<br>Prevent resorption atelectasis.<br>Augmented respiration. |
| Pulmonary Hemorrhage | Maintain clear airways.<br>Provide adequate oxygenation.<br>Prevent atelectasis and infection. |
| Croup | Reduce laryngeal edema.<br>Provide adequate oxygenation.<br>Prevent infection. |
| Bronchiolitis | Clear airways (liquefy inflammatory exudate in bronchioles).<br>Bronchiolar dilatation.<br>Combat infection. |
| Pneumonia | Provide adequate oxygenation.<br>Liquefy secretions.<br>Combat infection. |
| *Asthma | Maintain clear airways. Promote bronchial drainage. Intermittent positive pressure breathing. |
| *Chronic cough Bronchitis | Bronchial dilatation and drainage.<br>Combat infection. |
| *Bronchiectasis | Maintain clear airways. Promote bronchial drainage. Control infection. Consider surgical excision. |
| *Mucoviscidosis | See asthma. Combat atelectasis and bronchiectasis. Control acute and chronic infection, prevent chronic anoxia. Bronchoscopy as indicated. |
| Poliomyelitis | Reconditioning of elastic and muscular forces. Maintain clear airways. Control infection. |

*Pre-emphysema may exist in any of these conditions; therapy to prevent full-blown secondary emphysema should be aimed at intensive treatment of the primary bronchopulmonary disease.



REQUISITION – NOTES & CHARGES

INHALATION THERAPY

BATAAN MEMORIAL METHODIST HOSPITAL

TICKET NUMBER 5034

DOCTOR'S ORDERS

DIAGNOSIS

NURSE

| TIME | TREATMENT RECEIVED | SIGNATURE | ITEM | AMOUNT |
|---|---|---|---|---|
| | | | EQUIPMENT | |
| | | | MEDICATION | |
| | | | AMOUNT | |
| | | | HOURS | |
| | | | OTHER | |
| | | | | |
| | | | | |
| | | | DAILY TOTAL | |

Paper Pad by NCR CO

Speedset by Moore Business Forms, Inc.

*INHALATION THERAPY CARD*

THIS PATIENT HAS

_____

and is to be treated with IPPB Therapy:

AEROSOL MIXTURE

Isuprel _____ _____ cc

Other _____ _____

Dist. $H_2O$ _____

PRESSURE _____ cm TIME _____ min

_____ M.D.

E-7

## INDICATIONS FOR INHALATION OF OXYGEN

1. Correction of Anoxemia or Anoxia
2. Diagnosis of Anoxemia
3. Elimination of Gas From Body Cavities

## EFFECTS OF INHALATION OF OXYGEN

1. Blood $O_2$ (↑)
2. Body $N_2$ (↓)
3. $PCO_2$ (↓)
4. Respiration (↓ RR, TV, RMV)
5. Circulation (↓ HR, Output)
6. Blood Formation (RBC ↑ or )

## SUGGESTED OXYGEN THERAPY

1. Use Lowest Concentration to Relieve Anoxemia
2. Oximetry
   a. Note maximal level with 100% $O_2$
   b. Determine lowest concentration which produces maximal level
3. Usually 35-50% $O_2$ Suffices
   a. Can be given indefinitely without $O_2$ toxicity
   b. Short intermittent periods

## METHODS FOR ADMINISTERING OXYGEN

1. Atmosphere
2. Nasopharyngeal
3. Maxk or Cuffed Endotracheal Tube
4. Tent
5. IPPB

*Comparison of Oxygen Administration*

| | Approximate Per Cent $O_2$ at Alveolar Level | L./min. Flow of $O_2$ Required | $CO_2$ Accumulation (at 8 L. $O_2$ Flow) |
|---|---|---|---|
| Rubber oronasal mask | 40 | 4 | Yes |
| (BLB) | 50 | 6 | |
| (OEM) | 55 | 8 | |
| | 60 | 10 | |
| Plastic face mask | 30 | 4 | No |
| Nasal catheter | 40 | 5 | |
| Face tent | 45 | 8 | |
| Nasal cannula | 50 | 10 | |
| $O_2$ tent | 25 | 6 | No |
| | 35 | 10 | |
| | 43 | 15 | |

## POSSIBLE HARM FROM OXYGEN INHALATION

1. Cessation of Respiration
2. Depression of Ventilation
3. Pulmonary Irritation
4. Atelectasis
5. Retrolental Fibroplasia, Hyaline Membrane
6. Oxygen Toxicity

## INDICATIONS FOR I.P.P.B. THERAPY

1. Physiologic

   Airway Obstruction Due To:

   - Bronchospasm
   - Secretions
   - Mucosal Edema
   - Alveolar Exudate

   Inadequate and Unequal Alveolar Ventilation

   Respiratory Acidosis

   Respiratory Arrest

   Increased Work of Breathing States

2. Clinical Conditions

   Infants

   Acute

   Chronic

   Surgery

   Postoperatively

3. Special Circumstances

   Preoperative Preparation

   Fixed Partial Airway Obstruction

   "Flail Chest"

   Paralyzed Diaphragm

   NM or Skeletal Disease

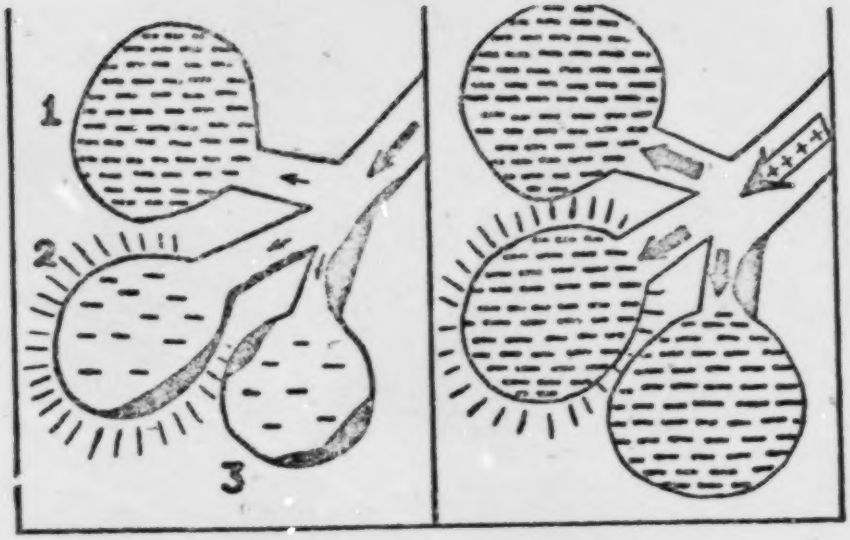
## EFFECTS OF I.P.P.B. THERAPY

1. Mechanical Ventilation
   - ↑ TV and RMV
   - More Uniform Distribution
   - ↑ Alveolar Ventilation with ↑ $PO_2$
   - Facilitates $CO_2$ Elimination
   - Permits Respiratory Acid-Base Regulation
   - Decreases Work of Breathing

2. Aerosol Therapy Vehicle

3. Expectorant Effect

4. CV Effects
   - ↑ Arterial and Tissue $O_2$ Tension
   - Control Peak Pressure Levels
   - Control Expiratory Phase



# METHODS OF DELIVERING I.P.P.B.

Assisted Breathing

- Mouth-to-mouth Resuscitation
- Pursed Lip Breathing

Simple Devices

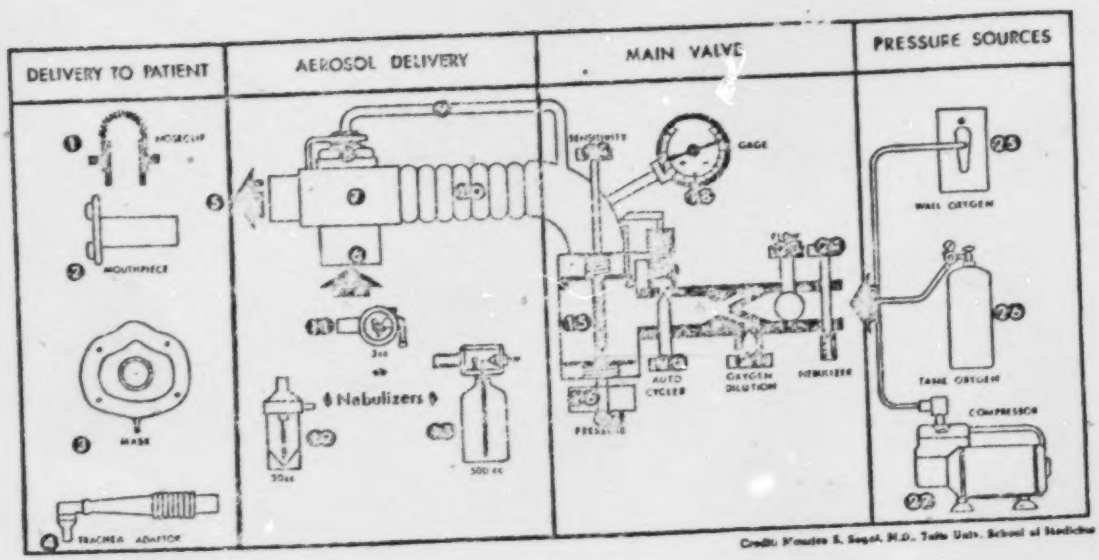
- Hand Nebulizers
- Bicycle Pump

IPPB Machines

- Emergency Resuscitators
- IPPB Therapy Units

Respirators

- Intermittent
- Continuous



## THE I.P.P.B. PRESCRIPTION

Place of Treatment

Type of Equipment

- Basic
- Modified

Frequency and Duration

Inspiratory Pressure

Gas Mixtures

Aerosol Medications

## CONTRAINDICATIONS TO I.P.P.B. THERAPY

Absolute

- Massive Pulmonary Hemorrhage

Relative

- Less Massive Hemoptysis
- Pneumothorax
- Active Pulmonary TBC
- Cystic Fibrosis (Guarded)
- Subcutaneous Emphysema
- Hyperventilation States

## HAZARDS AND PRECAUTIONS FOR I.P.P.B. THERAPY - 1

Inadequate Equipment

Inadequate Training and/or Supervision

Respiratory Alkalosis ( ↓ RR)

Bullous Emphysema (Air embolism)

Careful Selection of Bronchodilator for Coronary Cases

Patients in Coma - Gastric Distention

## HAZARDS AND PRECAUTIONS FOR I.P.P.B. THERAPY - 2

Postoperative Abdominal Surgery

Palpitation

Humidification

Excessive Nebulizer Flow

Bronchospasm or Paroxysmal Cough

(New medications, allergies)

Bacterial Contamination

## OUTPUT CHARACTERISTICS OF SMALL RESERVOIR UNITS OPERATING ON DeVILBISS PUMP

| NEBULIZER | ΔP psi | FLOW RATE L/m | OUTPUT μL/L | MASS MEDIAN DIAMETER, μ | STANDARD DEVIATION |
|---|---|---|---|---|---|
| VPF | 12.0 | 4.0 | 29.3 | 5.6 | 1.8 |
| BTJ-R | 7.5 | 5.0 | 23.8 | 6.8 | 1.8 |
| BTJ-L | 7.5 | 4.9 | 30.4 | 7.7 | 1.8 |
| DV-640 | 5.0 | 5.1 | 23.2 | 6.3 | 1.9 |
| DV-X | 5.0 | 5.5 | 9.6 | 4.9 | 2.0 |
| MOG-ET-IT | 14.0 | 3.5 | 11.2 | 3.9 | 1.8 |
| MOG-GTJ | 5.0 | 4.6 | 19.2 | 8.9 | 2.1 |
| MOG-P | 16.0 | 3.1 | 31.1 | 6.1 | 1.9 |

## OUTPUT CHARACTERISTICS OF LARGE RESERVOIR UNITS OPERATING ON PURITAN PUMP

| NEBULIZER | ΔP psi | FLOW RATE L/m | OUTPUT μL/L | MASS MEDIAN DIAMETER, μ | STANDARD DEVIATION |
|---|---|---|---|---|---|
| P 126-051 (40mm) C | 23 | 10 | 26.6 | 6.5 | 1.9 |
| P 126-051 (40mm) H | 23 | 10 | 28.3 | 5.7 | * |
| MOG-MC-11c | 30 | 5.1 | 23.0 | 3.5 | 1.9 |
| MOG-VT-11c | 30 | 5.1 | 75.0 | 6.7 | 1.7 |

* Not log-normally distributed

VPF Vaponefrin
BTJ Bennett Twin Jet
MOG-ET Mist-$O_2$-Gette
P Puritan
MOG Mist-$O_2$-Gen

DROPLET SIZE DISTRIBUTION DATA FOR MIST-$O_2$-GEN AND DEVILBISS NEBULIZERS

| Nebulizer | Number of Samples | Droplet Size Distribution Parameters: Mass Median Diameter | Droplet Size Distribution Parameters: Approximate Geometric Standard Deviation |
|---|---|---|---|
| Mist-$O_2$-Gen - reservoir | 10 | 6.5 μ | 1.4 |
| Mist-$O_2$-Gen - vial | 10 | 6.5 μ | 1.5 |
| DeVilbiss - Setting 1 & 2 | 20 | 5.7 μ | 1.5 |
| DeVilbiss - Setting 3 & 4 | 20 | 6.9 μ | 1.6 |

OPERATIONAL DATA OF THE NEBULIZERS

| UNIT | OPERATING FREQUENCY* | FLOW RATE THROUGH NEBULIZER | SOLUTION VOLUME IN NEBULIZER CUP |
|---|---|---|---|
| DeVilbiss | 1350 kc/s | 41.0 L/m | 50 ml** |
| Mistogen | 1400 kc/s | 24.7 L/m | 10 ml (no reservoir)<br>60 ml (with reservoir) |
| Mead Johnson | 800 kc/s | adjustable | 13 ml |

*Manufacturer's specification
**For one liter in reservoir

## INHALATION THERAPY EQUIPMENT

OXYGEN REGULATION APPARATUS

- Pressure Reducing Valves
- Flow meters
  - Baudon gauge
  - Pressure Compensatory Thorpe tube
    - Puritan Flowmeter

OXYGEN/HUMIDITY TENTS

- Mistogen Aquastream
- Ohio Controlled Atmosphere Unit
- Airshields Universal Croupettes
- NCG Aerosol Tent
- DeVilbiss Aerosol Tent - Home model

INTERMITTENT POSITIVE PRESSURE BREATHING DEVICES

- Bennett PR-2
- Bennett AP-5
- Bird Mark 7
- Bird Mark 1

RESPIRATORS

- Emerson Ventilator
- Bennett MA-1
- Bird MG Minute Volume Ventilator

ULTRASONIC NEBULIZERS

- DeVilbiss 3584
- V. Mueller USN
- Mistogen EN140

PEDIATRIC RESUSCITATORS

G. B. L.

Elder Demand Valve

Puritan Manual Resuscitator

Amsterdam Infant Resuscitator

Bourne Pediatric Resuscitator

# APPENDIX F

## PULMONARY FUNCTION AIDS

# LABORATORY STUDIES OF PULMONARY FUNCTION FOR CHILDREN

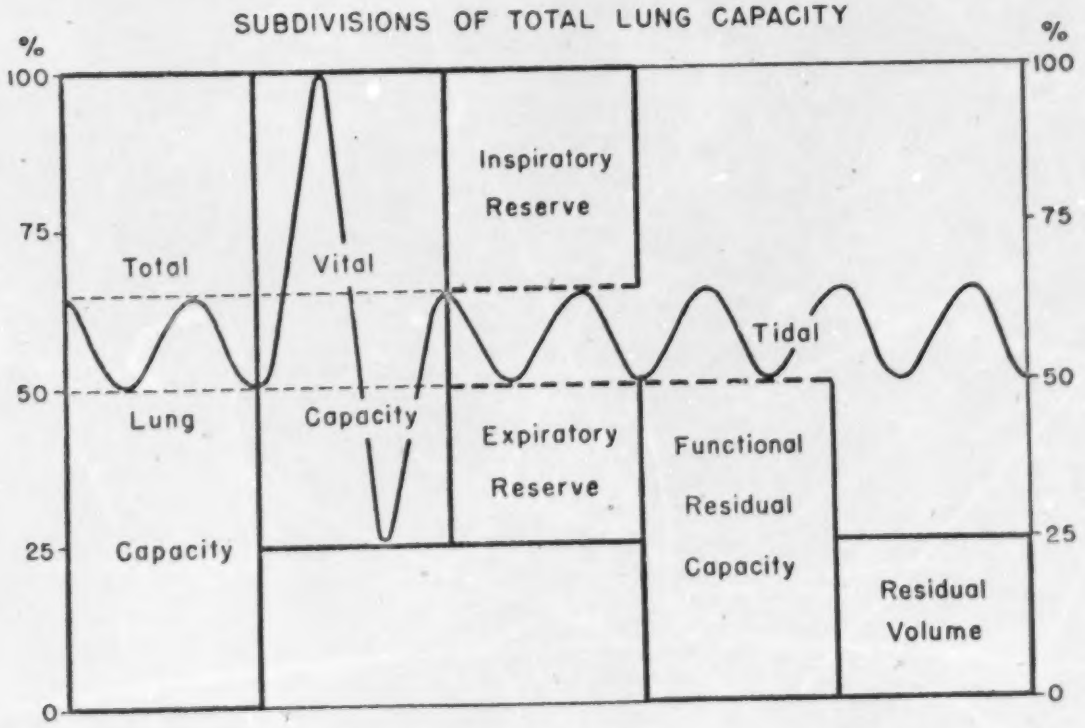
Pneumotachograph or Screening Studies of Air Flow

Lung Volumes

Functional Residual Capacity and Intrapulmonary Mixing and Distribution

Flow-Volume Studies

Physical Competence




F-2

PREDICTED VALUES FOR MAXIMUM BREATHING CAPACITY IN CHILDREN

GIRLS (Ferris & Smith, Ped. 12:343-344, 1953)

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO BODY SURFACE AREA IN METERS$^2$

| B.S.A., $M^2$ | 0.60-0.79 | 0.80-0.89 | 0.90-0.99 | 1.00-1.09 | 1.10-1.19 | 1.20-1.29 | 1.30-1.39 | 1.40-1.49 | 1.50-1.59 | 1.60-1.69 | 1.70-1.79 | 1.80-1.89 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean, LPM | 41.9 | 53.0 | 59.6 | 63.3 | 69.8 | 75.7 | 81.2 | 90.8 | 93.0 | 106.6 | 120.6 | 130.2 |

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO HEIGHT IN CENTIMETERS

| Ht., cm. | 100.0-109.9 | 110.0-114.9 | 115.0-119.9 | 120.0-124.9 | 125.0-129.9 | 130.0-134.9 | 135.0-139.9 | 140.0-144.9 | 145.0-149.9 | 150.0-154.9 | 155.0-159.9 | 160.0-164.9 | 165.0-169.9 | 170.0-174.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean, LPM | 41.5 | 45.2 | 49.0 | 61.7 | 57.9 | 62.1 | 72.0 | 73.7 | 77.9 | 89.8 | 94.7 | 102.7 | 107.3 | 124.3 |

F 13

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO AGE IN YEARS

| Age (yrs.) | 5.0-5.9 | 6.0-6.9 | 7.0-7.9 | 8.0-8.9 | 9.0-9.9 | 10.0-10.9 | 11.0-11.9 | 12.0-12.9 | 13.0-13.9 | 14.0-14.9 | 15.0-15.9 | 16.0-16.9 | 17.0-17.9 | 18.0-18.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean, LPM | 41.2 | 52.6 | 52.8 | 60.3 | 67.0 | 71.9 | 79.3 | 95.8 | 103.9 | 99.4 | 105 | 92.0 | 108.3 | 123.1 |

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO WEIGHT IN KILOGRAMS

| Wt. (kg.) | 15.0-19.9 | 20.0-24.9 | 25.0-29.9 | 30.0-34.9 | 35.0-39.9 | 40.0-44.9 | 45.0-49.9 | 50.0-54.9 | 55.0-59.9 | 60.0-64.9 | 65.0-69.9 | 70.0-74.9 | 75.0-79.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean, LPM | 36.0 | 53.0 | 60.7 | 65.0 | 77.6 | 77.3 | 87.6 | 97.6 | 100.0 | 105.9 | 97.9 | 126.3 | 131.7 |

## PREDICTED VALUES FOR MAXIMUM BREATHING CAPACITY IN CHILDREN

### BOYS (Ferris, Whittenberger & Gallagher, Ped. 9:661-662, 1952)

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO BODY SURFACE AREA IN METERS$^2$

| B.S.A., $M^2$ | 0.70-0.89 | 0.90-0.99 | 1.00-1.09 | 1.10-1.19 | 1.20-1.29 | 1.30-1.39 | 1.40-1.49 | 1.50-1.59 | 1.60-1.69 | 1.70-1.79 | 1.80-1.89 | 1.90-1.99 | 2.00-2.09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean, LPM | 46 | 48 | 65 | 70 | 79 | 84 | 93 | 108 | 110 | 130 | 130 | 125 | 148 |

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO HEIGHT IN CENTIMETERS

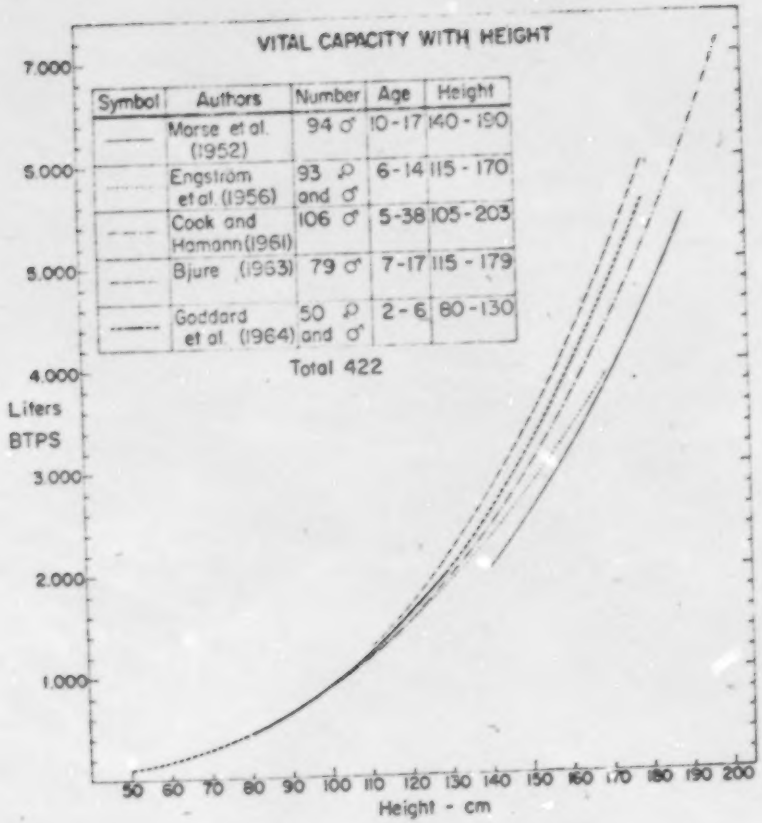
| Ht. (cm.) | 110.0-119.9 | 120.0-124.9 | 125.0-129.9 | 130.0-134.9 | 135.0-139.9 | 140.0-144.9 | 145.0-149.9 | 150.0-154.9 | 155.0-159.9 | 160.0-164.9 | 165.0-169.9 | 170.0-174.9 | 175.0-179.9 | 180.0-184.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean, LPM | 44 | 45 | 63 | 69 | 68 | 79 | 82 | 86 | 102 | 115 | 113 | 127 | 129 | 148 |

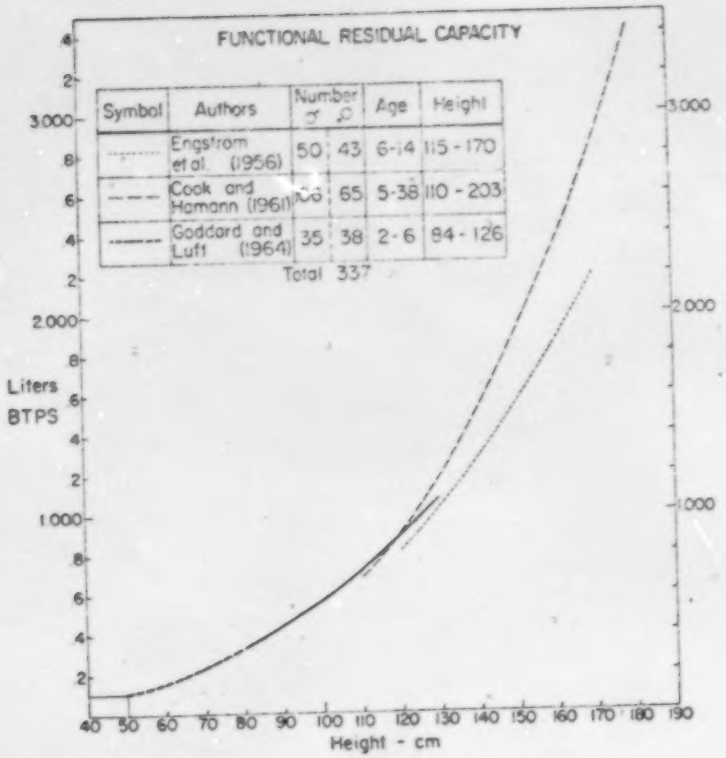
MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO AGE IN YEARS

| Age (yrs.) | 5.0-5.9 | 6.0-6.9 | 7.0-7.9 | 8.0-8.9 | 9.0-9.9 | 10.0-10.9 | 11.0-11.9 | 12.0-12.9 | 13.0-13.9 | 14.0-14.9 | 15.0-15.9 | 16.0-16.9 | 17.0-17.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean, LPM | 42 | 45 | 65 | 69 | 73 | 79 | 85 | 109 | 117 | 117 | 129 | 134 | 155 |

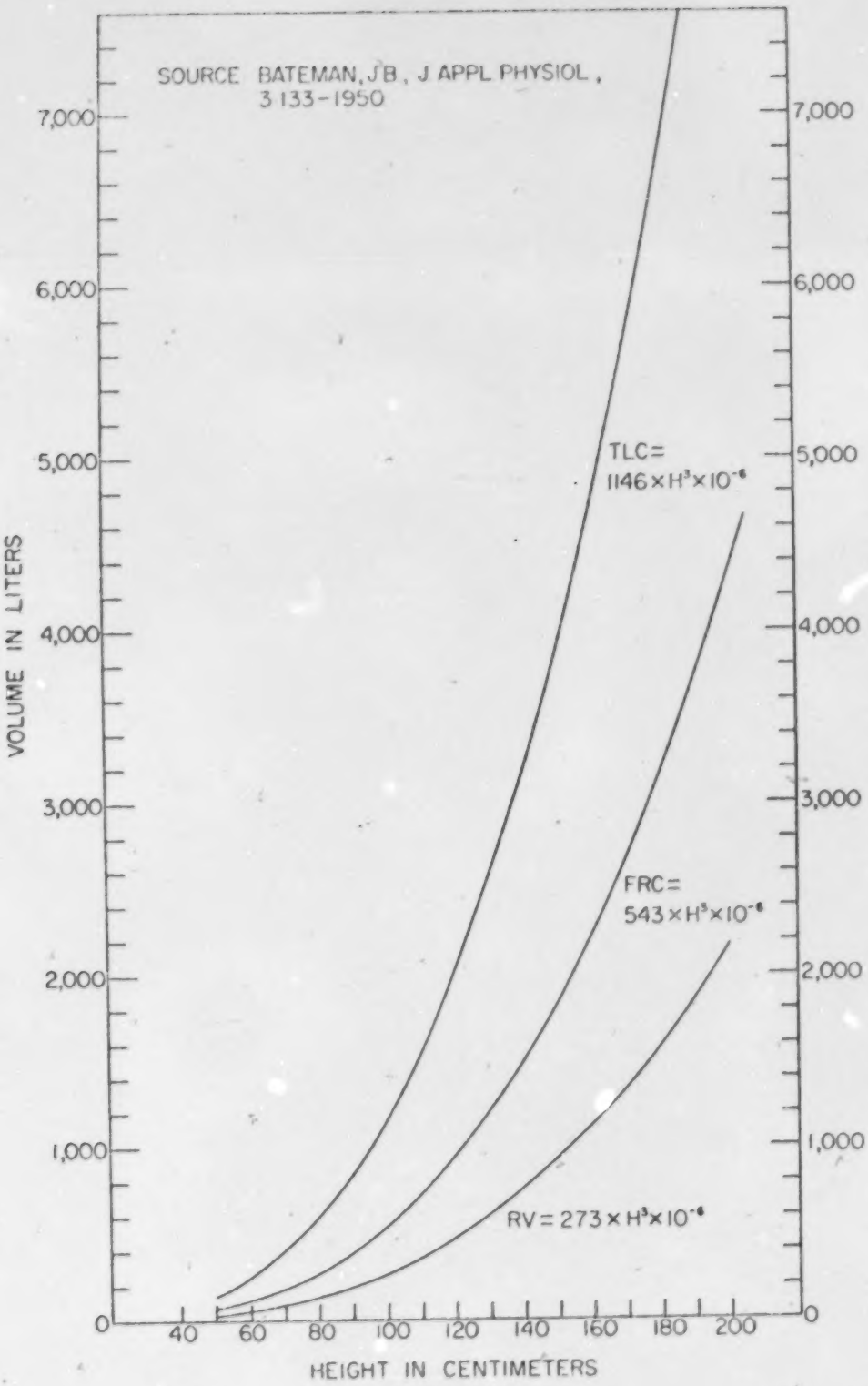
MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO WEIGHT IN KILOGRAMS

| Wt. (kg.) | 20.0-24.9 | 25.0-29.9 | 30.0-34.9 | 35.0-39.9 | 40.0-44.9 | 45.0-49.9 | 50.0-54.9 | 55.0-59.9 | 60.0-64.9 | 65.0-69.9 | 70.0-74.9 | 75.0-79.9 | 80.0-84.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean, LPM | 46 | 53 | 74 | 71 | 83 | 93 | 110 | 121 | 129 | 119 | 126 | 122 | 136 |

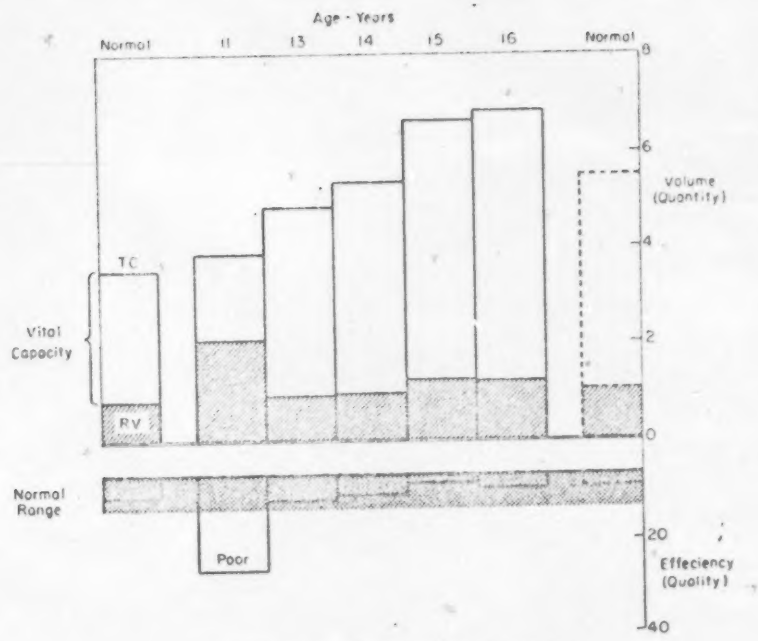




FUNCTIONAL RESIDUAL CAPACITY
Symbol | Authors | Number ♂ ♀ | Age | Height
Engstrom et al. (1956) | 50 43 | 6-14 | 115-170
Cook and Hamann (1961) | 66 65 | 5-38 | 110-203
Goddard and Luft (1964) | 35 38 | 2-6 | 84-126
Total 337
Liters BTPS
3.000
2.000
1.000
40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
Height - cm

CORRELATION OF VITAL CAPACITY AND FUNCTIONAL RESIDUAL CAPACITY WITH HEIGHT
(from Goddard, R. F. and Luft, U. C., Pulmonary Function Tests for Infants and Children, p. 24. see also regression curves on page 9, Starline Corp., 1969.)


SOURCE BATEMAN, J.B., J APPL PHYSIOL., 3 133-1950
VOLUME IN LITERS
HEIGHT IN CENTIMETERS
TLC= 1146 × H³ × 10⁻⁶
FRC= 543 × H³ × 10⁻⁶
RV = 273 × H³ × 10⁻⁶
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
40
60
80
100
120
140
160
180
200

F-6




PERIODIC PULMONARY FUNCTION STUDIES IN
ADOLESCENT ASTHMATIC

# SIMPLIFIED PULMONARY FUNCTION TESTS FOR THE OFFICE AND HOSPITAL

## Single Value Studies

## Multiple Value Studies

# CALCULATION OF VC AND FEV

(AC)

$FEV_{1sec} = 16.25 \times .2255 = 3.66\ L$

(AB)

$VC = 18.5\ cm \times .2255 = 4.17\ L$

$$\frac{FEV_1}{VC} \times 100 = \frac{3.66}{4.17} \times 100 = 88\%$$ or

FEV is 88% of VC

Paper Speed = 1cm/sec

# CALCULATION OF MMEF

Paper Speed = 1 cm/sec

(FG) (DE)
Middle 50% of VC

9.3 cm × .2255 = 2.10 L

Time calc. for middle 50% of VC

$$\frac{.45\,\text{cm}}{1\,\text{cm/sec}} = 0.45\,\text{sec}$$

MMEF = 2.10 L/0.45 sec = 4.67 L/sec

CALCULATION SHEET

Name_____ Age_____ Date_____

Height_____ Weight_____ B.s.a._____

VC _____ cm x (.2255)* = _____ L BTPS

$FEV_1$ _____ cm x (.2255) = _____ L BTPS

$\frac{FEV_1}{VC}$ x 100 = _____ = _____ %

MBC = $FEV_1$ (L BTPS) x 37 = _____ L BTPS

MMEF = $\frac{cm \times (.2255)}{sec}$ = _____ L/sec

*Spirometer factor for converting cm into L and correcting gas to BTPS (at temperature of 24°C and barometric pressure of 630 mmHg.)

$\frac{\text{Measured VC}}{\text{Predicted VC}}$ = _____ x 100 = _____ %

$\frac{\text{Measured MBC}}{\text{Predicted MBC}}$ = _____ x 100 = _____ %

Operator:_____ Calculator:_____ Check:_____

PULMONARY FUNCTION TEST

Hospital _____ or Office: _____

Physician's Name _____

Patient's Name _____

Age _____ Height _____ Weight _____

Brief History of the Pulmonary Problem _____

_____

_____

_____

Clinical Diagnosis _____

_____

Pulmonary Function Results:

| Volume | Measured | Predicted | Meas./Pred. |
|---|---|---|---|
| VC | | | |
| IC | | | |
| ERV | | | |
| MBC | | | |
| $FEV_1$ | | | |
| $\frac{FEV_1}{VC} \times 100$ | | | |

Interpretation of Test _____

_____

_____

_____

Date of Test _____ Technician _____

Signed _____

M. D.

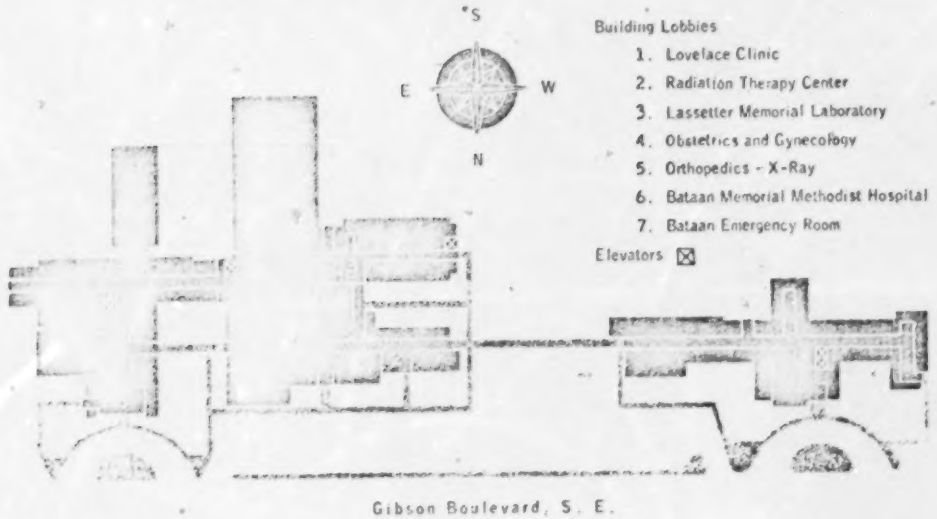
INSTRUCTIONS FOR PERFORMING TIMED VITAL CAPACITY, MMEF AND MBC TRACING

Timed Vital Capacity, MMEF and MBC Tracing.

All the information for calculations of VC, $FEV_1$, MMEF and MBC are obtained from this single maneuver:

1. Let the spirometer bell go all the way down.
2. Instruct the patient to inhale as deeply as possible from the room air.
3. Turn on kymograph motor and immediately
4. Let the patient exhale into spirometer mouthpiece as rapidly and completely as possible.
5. Have patient remove mouthpiece from mouth after complete exhalation.

Repeat two or three times.




Bataan Memorial Methodist Hospital — Lower Level
Rehabilitation Center
Pediatric Pulmonary Center

Departments of Lovelace Clinic — First Floor
Department of Radiology
Department of Orthopedics

Departments of Lovelace Foundation — Second Floor
Department of Physiology
Aging Research Project
Environmental Psychology
Pediatric Research

Instrumentation Laboratory — Third Floor
Pathology Research Laboratory

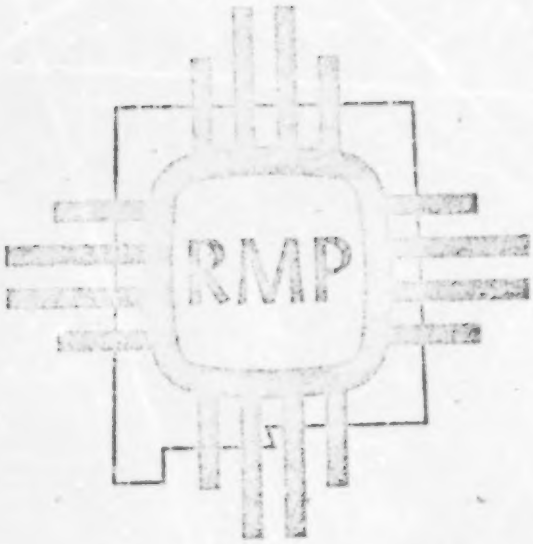
Department of Aerospace Medicine — Fourth Floor
Department of Biomathematics
Department of Physics
Document Library
Computer

Departments of Lovelace Clinic
Section of Hematology — First Floor
Department of Laboratories
Section of Clinical Pathology
Section of Biochemistry — Second Floor
Section of Anatomical Pathology — Third Floor
Section of Microbiology

Departments of Lovelace Foundation
Department of Medical Illustration — Lower Level

Medical Library — Fourth Floor
Office of Director of Research
Office of Director of Administration and Business Offices

The lobby on the first floor of this building is the Albert [illegible] Collection of Western Art consisting of paintings and illustrations by the famous artists, Fredric Remington and [illegible]




NEW MEXICO REGIONAL MEDICAL PROGRAM